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NOVEMBER 1991

CHILTON'S AUTOMOTIVE INDUSTRIES

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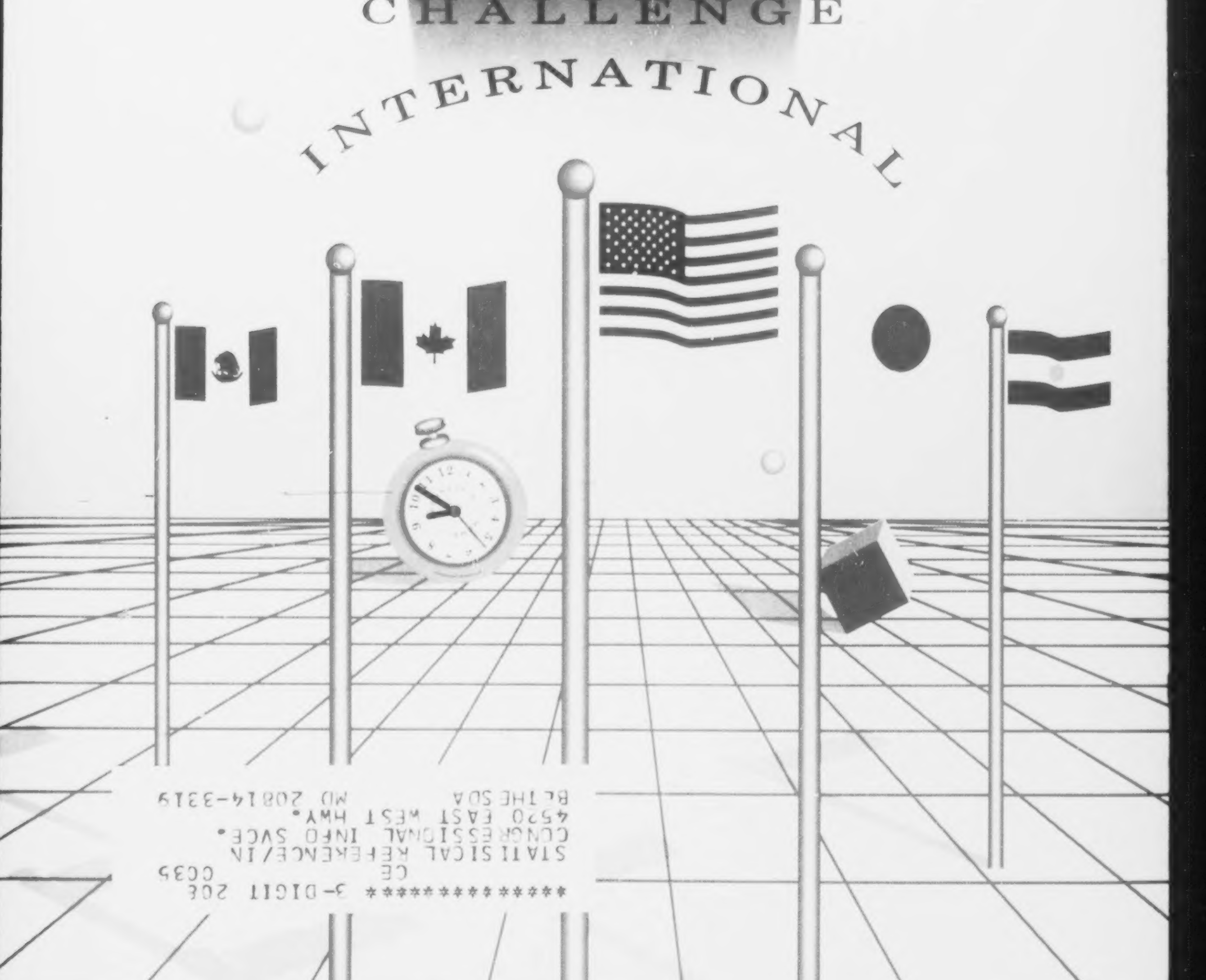
6th ANNUAL
DIE CHANGE CHALLENGE
INTERNATIONAL



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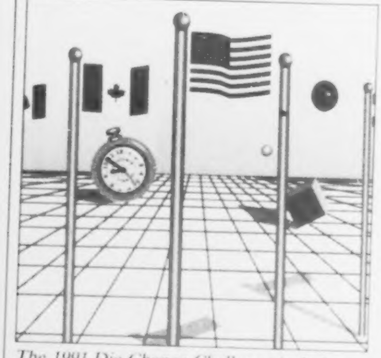

The 1991 Die Change Challenge includes Japan, Argentina, Canada, Mexico and the US. Page 26. Cover illustration by Robert Bernstein

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CHILTON'S
AUTOMOTIVE
INDUSTRIES

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An international focus with more plants and more teams.

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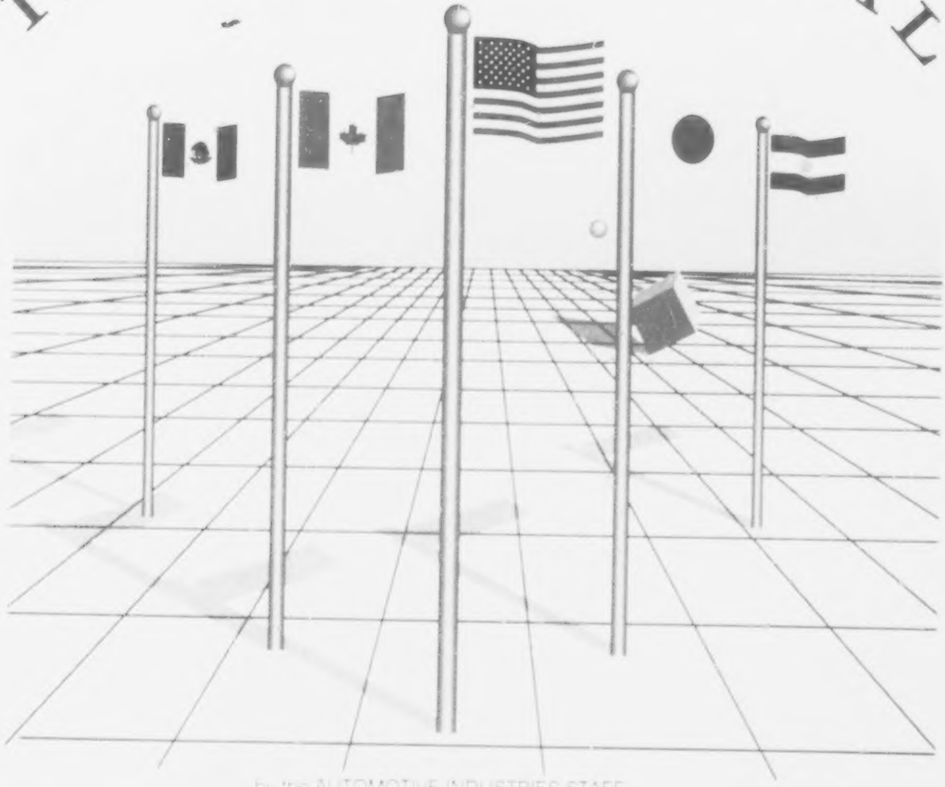
6th ANNUAL

DIE CHANGE CHALLENGE

INTERNATIONAL



by the AUTOMOTIVE INDUSTRIES STAFF

Every year the Die Change Challenge gathers momentum. We get more plants that want to enter. More teams that want to participate. And, measured on a geographical basis, more countries that are represented.

This year we received entries from Argentina and Japan – in addition to the United States, Mexico and Canada – which has given the competition a truly international flavor. And as you might expect, the intensity and creativity of the participants has risen to a new level.

In fact, we were caught completely off guard by just how creative these people can be. The rules of the Die Change Challenge stipulate that the most efficient team will be declared the winner in each category and in the overall classification. We calculate this efficiency by multiplying the number of people on the team by the time it took to do the die change. Obviously, the fewer people involved, the more efficient the team becomes.

Well, much to our surprise, there were four plants that entered this year which didn't have anyone on their team! That's right, there were able to completely automate the process. They developed a software program that counts the number of blanks that runs through the pressline and once the pre-programmed number of blanks have gone through, the press automat-

MORE PLANTS, MORE TEAMS, MORE INTERNATIONAL

ically changes dies and starts making new parts.

The plants that did this included BOC's plant in Lansing, MI, Ford's plant in Walton Hills, OH, and CPC's plants in Parma, OH and Oshawa, Ontario.

Needless to say, this produced a lot of discussion on the *AI* staff regarding how we should interpret the rules. In the end we decided to include the person who actually sat down at the computer and entered the number of blanks to be counted as a member of the team. After all, there are other plants where the die change is done automatically after one person pushes a button on the control panel. But even so, our hats are off to these people. They are amazingly creative.

The whole process of visiting 18 plants in five different countries was squeezed in over a six month period. And each team at each plant treated us to a valuable lesson in how people working together can achieve significant improvements in productivity. We're sure you'll enjoy each story.

TRANSFER LINES

Ford Walton Hills

You know there's something different about the Walton Hills die change right from the start. It's not the equipment or the panels they run, it's the stern look on the face of the one-man die change team – Mark Aster. And if that's not enough, ponder this. His fellow employees affectionately refer to him as "God."

We arrived early enough to time a three-minute practice run, and while we were impressed by the savings in man minutes that it represented over last year's effort, Aster didn't agree. In fact, he glared at the slow-to-engage main motor and issued an unspoken threat.

Now at peace with his equipment, Aster indicated that he was ready for the Die Change Challenge. The clock started. The equipment moved quickly as he ran the carts into the press. All the while he continued to glare at the main motor.

With new dies in place and the gates closed, Aster pushed the button to start the press. The motor responded instantly, and in 2:24 the first panel was on the conveyor.

In a meeting that followed, Aster told *AI* that we had just seen the fastest time ever run by that line. "We're pretty much to the limit of the press," Aster said. "It's to the point of no payback." He added that even in normal day-to-day die changes, the line is running five or six minutes with only two or three people.

But having said that, he did note that they could put more air to the die carts, pump up the programming and maybe stop the rams short to get under the two minute mark. "Yeah," he said with a smile. "Next year we could be under two minutes. Then we could work on eliminating me!"

Diamond-Star

We expected quick times from Diamond-Star, and we got them. We also got something of an impromptu battle between the first and second shifts.

Line A was staffed by Terry Campbell, a member of the plant's first shift, while Line D had Jeff Gardner at the controls. Campbell, who ran first, went from the Eclipse Laser/Talon tailgate upper outer panel to the same vehicle's right hand door outer, while Gardner changed from a Mirage/Summit trunk outer upper panel to an Eclipse, etc. lower tailgate outer. Each was at the controls of a Komatsu fully automatic transfer line running hot-rolled coated steel.

Campbell's run was executed flawlessly, the process over almost before it began. At three-quarters of a second under three minutes, Campbell had set a time Gardner was going to have to work hard to beat. This despite the fact that the crew on Gardner's line had already modified the automation reset, and adjusted the timers that bring the bolsters into place.

And beat it Gardner would have – if the cushion pads had deployed on cue. But they didn't. Gardner was then forced to wait for the die change to finish before he could switch to manual, enter the "garage doors," and raise the pads. That glitch, he surmised, was worth 15 seconds. He turned a 3:08.56, but ran second to Campbell.

C-P-C Parma

Why is everyone smiling? Why are there so many people standing around? Why does it seem like everyone knows something that we don't? Are we missing something?

Well, no. Actually it's Parma that's missing something – people! There're no people on this die change!

It had to happen sooner or later. A little tweak from the tool and die folks, a little commonized tooling, some rewriting of the software and...presto! The transfer press runs its last right-hand W-Car longitudinal rail, a siren sounds, the dies change and boom, boom, boom – out come left-hand rails.

To make matters worse, Parma has even made *AI*'s job unnecessary. How? At the end of the die change, our watch stopped at 4:17. "What time did we do?" yelled one of the workers. But before we had a chance to answer, he looked at the control monitor and said "Oh, 4:17, not bad."

Yup, you guessed it. This thing times itself too!

In a meeting that followed, the team members that made the unmanned die change possible said they asked what the rules were and just worked within them. They said all of the software wizardry was done in-house, and while

they weren't eager to share with the outside world, they would be willing to pass secrets along to sister plants.

They obviously share their secrets internally. During our walk through the facility, we learned that the plant average die change time went from eight hours to less than one. And it's still going down!

That's music to our ears.

Ford Chicago

The road to a hands-off die change began when Ford's Chicago stamping plant crew looked at how to implement a demand-pull stamping operation run according to the daily output at each assembly plant it serves. This JIT system, they reasoned, would cut costs and delays, and make the Chicago stamping plant a 24-hour-a-day operation. But it took the help of the Square D Company, the Line 12 team and Ford manufacturing to make hands-off die changes a reality, and demand-pull operation a possibility.

Although there is an operator on Line 12, his only involvement in the die change procedure is to tell the computer how many panels to run before initiating the change. From the last panel off to start-up with the new die set, everything happens automatically – a process made abundantly clear when the workers stood with their hands behind their backs during the die change.

Even more amazing was that there was little of the expected rank-and-file resentment. In fact, the 12-man crew responsible for this line not only claims 'ownership' of it, but continues to push the envelope toward even faster die changes. "We're doing it so our kids have something to look forward to," said one participant.

So amid cheers from the onlookers, Line 12 went from an aluminum Grand Marquis hood outer to its Crown Victoria counterpart in 4:31, one minute under the group's original goal.

DIE CHANGE TIME COMPARISON

COMPANY	PLANT	CATEGORY	TIME
Hirotec	Hiroshima	Automated Tandem	1:27
B-O-C	Lansing	Automated Tandem	2:15
Ford	Hermosille	Automated Tandem	2:19
Ford	Walton Hills	Transfer	2:24
Honda II	Marysville	Automated Tandem	2:36
Diamond-Star I	Normal	Transfer	2:59
Diamond-Star II	Normal	Transfer	3:08
Nissan	Aguas Calientes	Transfer	4:11
C-P-C	Parma	Transfer	4:17
Ford	Chicago	Transfer	4:31
C-P-C	Oshawa	Transfer	5:42
Honda I	Marysville	Transfer	6:04
Chrysler II	Twinsburg	Automated Tandem	6:07
Honda	Alliston	Automated Tandem	6:22
B-O-C I	Pittsburgh	Manual Tandem	9:41
B-O-C II	Pittsburgh	Manual Tandem	10:04
C-P-C	Grand Rapids	Transfer	10:35
B-O-C	Buick City	Semi-Auto Tandem	10:47
C-P-C	Marion	Transfer	11:56
Renault II	Argentina	Manual Tandem	13:32
Renault I	Argentina	Manual Tandem	15:47
Chrysler I	Twinsburg	Automated Tandem	17:46
Cadillac	Grand Blanc	Manual Tandem	23:40

C-P-C Oshawa

With only two months to go before they would compete in the Die Change Challenge, the people at CPC Oshawa were starting to get concerned. Even though they had been steadily improving their time, it still took 60 operations and 45 minutes to do a die change – not good enough.

At this point the die change team decided it had to completely revamp its procedures. First of all they concentrated on reducing or eliminating all internal set-up. Andrew Odell, a tool and die maker in the plant, decided to modify the tooling inside the press so it could several different parts. He improved the flexibility of the tooling to such an extent that they now use just one blank for both parts instead of two.

This will add up to considerable cost savings over time and will help the plant reduce its inventory in blanks.

The tooling changes made to the press saved nearly 20 minutes, but that still left 25 minutes per die change – still too much.

At this point Fred Porringa, the plant's electrical and programming 'wizard,' tackled the automatic sequencing of the press. As originally designed in Japan, it took the press 15 minutes to go through its sequences. Porringa was able to reprogram the press line so that it now goes through those operations in only three minutes.

Not only has the plant improved its die change times, it has put that extra time into making more parts. "We don't seem to be scrambling as much for production," says Porringa.

Honda Marysville I

Just a week before we were scheduled to do Marysville's die changes, lightning struck a power station in nearby Urbana that sent a spike to the computer in the plant's D-Line. In the blink of an eye, the programming for the line was gone (What, no backup?) and the program from C-Line had to be downloaded to get the giant 4800-metric ton Hitachi Zosen up and running.

First attempts were futile and much of the programming had to be input by hand. The day prior to our arrival, the press was finally "bug-free," giving Honda only one day to practice.

The one-man die change was performed by Terry Nicol, who would oversee the change from Civic front door outers to Civic rear door outers. When the change started, everything seemed to be going Terry's way, as the press was moving toward a sub-five minute time. But after the new dies were in place, one of the blanks didn't set properly in the draw die and the sensors on the press wouldn't allow it to trip.

Nicol had to do some fast work as he shut off the press, raised the gates, adjusted the panel by hand and then reversed the procedure. When the first panel hit the conveyor at 6:04, it was about a minute later than if there hadn't been a glitch.

Undaunted, Nicol sees potential in making the clutches engage faster, and also in boosting hydraulic pressure to speed the transfer. He has ideas to get next year's time near the four minute mark.

Nissan Aguas Calientes

We were very pleased to have Nissan's plant in Aguas Calientes enter the Die Change Challenge. It gave us the opportunity to visit this massive manufacturing complex which has two engine plants, an aluminum foundry, a transaxle plant, a sheet-metal subassembly plant, and a stamping facility.

It also has a $1 billion car assembly plant under construction that will come on-line a year from now. Without a doubt, Nissan's Aguas Calientes plant is going to play a major role in the North American auto industry.

With production about to ramp up in the coming year, the stamping people are concentrating on making more parts on every press line. And quick die changes are playing a key role in achieving this production increase. For example, a year ago the Hitachi press that was entered in the Challenge was making 8000 to 9000 panels a day. But reducing the die change time created more production time. Now that press is capable of making 11,000 panels a day.

According to the team, the most important part of reducing its die change time was how the various groups in the plant contributed ideas. They got input from stamping and die engineering, maintenance, production, inspection and material handling. And as they implemented these ideas they were able to chip away at the 20 to 25 minutes it used to take to change dies. Now they can consistently change dies on this line in less than five minutes. "We can't just do this for the Die Change Challenge. It has to be a daily operation. And it will be," promises Gerardo Martinez, the die maintenance auxiliary supervisor.

C-P-C Marion

Six weeks before we arrived, it took one hour to do a die change at the C-P-C Marion, IN stamping plant. A scant 30 days before we showed up, Gene Pischoff – the man in the spotlight – had a personal best time of 38 minutes. But by the time we walked out the door, Pischoff stopped the clock in less than 12 minutes.

In that 30-day period, the first and second shifts, given the chance to rearrange the die change process, moved to simplify. Common tooling for left and right panels replaced separate pieces. Nesting fingers were replaced by pads. Bolt-on fiber optic connections were given T-handles. All control switches were moved to the master console. New stock was indexed to the line (a change worth three minutes alone). The bolster and rails were adjusted to a common speed. And the die clamping flow control valve was adjusted to take the 'bounce' out of the die. In all, the workers eliminated the need to change 42 pieces.

The air was electric as a nervous Pischoff moved faultlessly through his routine, and a large cheer erupted as the official time was announced:

OVERALL CLASSIFICATION

COMPANY	PLANT	CATEGORY	TOTAL EFFICIENCY (Employee-minutes)
B-O-C	Lansing	Automated Tandem	2.25
Ford	Walton Hills	Transfer	2.40
Diamond-Star I	Normal	Transfer	2.98
Diamond-Star II	Normal	Transfer	3.13
C-P-C	Parma	Transfer	4.28
Hirotec	Hiroshima	Automated Tandem	4.35
Ford	Chicago	Transfer	4.51
C-P-C	Oshawa	Transfer	5.70
Honda I	Marysville	Transfer	6.06
Honda	Alliston	Automated Tandem	6.36
Honda II	Marysville	Automated Tandem	7.80
Nissan	Aguas Calientes	Transfer	8.36
Ford	Hermosillo	Automated Tandem	9.26
C-P-C	Marion	Transfer	11.90
C-P-C	Grand Rapids	Transfer	21.16
Chrysler I	Twinsburg	Automated Tandem	24.40
Chrysler II	Twinsburg	Automated Tandem	71.00
B-O-C II	Pittsburgh	Manual Tandem	100.60
B-O-C I	Pittsburgh	Manual Tandem	106.50
B-O-C	Buick City	Semi-Auto Tandem	194.10
Renault II	Argentina	Manual Tandem	203.00
Renault I	Argentina	Manual Tandem	236.70
Cadillac	Grand Blanc	Manual Tandem	331.30

11:56.50. Once the ice was broken, workers from other lines talked of taking up the die change gauntlet, and plans were made for monthly in-plant challenges and procedural documentation of further changes. Yes, competition does indeed improve the breed.

C-P-C Grand Rapids

Tom Bouwens and Wally Hodges were ready. Just an hour before we arrived they had pulled off a 7:02 die change, before tweaking the machinery a little more. Talk ran rampant of a six minute die change.

The catwalk above was crowded with noisy spectators as Bouwens and Hodges paced the floor like sailors in the last minutes of a three-day leave. They would be going from the right rear Caprice sedan door outer to its station wagon counterpart, and were anxious to start.

In no time flat Bouwens was flying around the double-action press at the start of the massive chain. Hodges, meanwhile, went to work inside the "garage doors" where the rest of the machinery lay. And then, just about five minutes into the change and with a sub-six minute time within reach, everything ground to a halt.

The changes made after the morning run (said to be good for 35 seconds) threw the timing off, causing a chair table to hit one of the shovels, closing one contact and opening another. Agonizing minutes passed as the trouble was traced, retraced and finally corrected.

But by this time it was too late. The damage had been done. When the first panel finally exited the maze, more than ten minutes had passed. Bouwens and Hodges were downcast. But true to the competitive spirit of the Die Change Challenge, both vow to return next year.

MANUAL TANDEM LINES

B-O-C Pittsburgh I

You have to give credit where credit is due, and the people of BOC Pittsburgh have a lot coming. First you have to realize that this was one of the plants GM had scheduled to close. But the management and workers concocted a brilliant scheme for survival.

They proposed that they stamp all the service parts for the various GM divisions. And after putting together a viable business plan that showed they could be very cost effective—that's exactly what they're doing. Right now they're even looking for business outside of GM.

Dies at Pittsburgh run a wide spectrum of sizes, styles, age and shut heights. And because the lots tend to be very small, efficient die change is an important part of the Pittsburgh culture.

The plant entered two shifts, both using the same line. The first shift changed from right-hand to left-hand Grand Am fenders. The second shift changed back.

On a difficult six-press tandem line with manual loading, the first shift's 11 team members rattled off a very respectable 9:41 die change. There was, however, a glitch. And it would turn out to be a disastrous omen for the second shift.

During the die transfer, one of the ears broke off the sub-plate and the die was stuck halfway in the press. Some quick thinking pushed it through with the back die cart, but what went unnoticed was the fact that it sheared off the bronze guides on the bottom of the plate.

For the first shift, the problem added an extra minute to the die change time. But for the team that followed....

B-O-C Pittsburgh II

Working with the same equipment they inherited from the first shift, the second shift launched into a 10-person die change. Like the first shift, the team knew that the die carts had new and faster gearing. And to give themselves a bit of an edge, the second team made some program changes to speed the conveyors.

But no sooner had the die change started, when disaster struck. Because the first shift had unknowingly sheared off the guides during its die change, the sub plate wouldn't hold a straight line during transfer. It

TRANSFER LINES

TIME	TEAM	PEOPLE	PRESS	BOLSTERS	PANELS	STEEL	UNION
2:24	Ford Walton Hills	1	Hitachi-Clearing	1	Rocker to Valence	National + USX	UAW 420
2:59	Diamond-Star I	1	Komatsu	2	Hatch to Door	Nippon	UAW 2488
3:08	Diamond-Star II	1	Komatsu	2	2-dr to 4-dr Decklid	Nippon	UAW 2488
4:11	Nissan Mexico	2	Hitachi-Zosen	1	4-dr to 2-dr Rocker	Nippon	STM
4:17	CPC Parma	1	Komatsu	3*	RH to LH Rail	Inland	UAW 1005
4:31	Ford Chicago	1	Komatsu	2	Crown Vic to Gran Marquis	Alcoa Alumin.	UAW 588
5:42	CPC Oshawa	1	IHI	3*	Coupe to sedan decklid	Dofasco	CAW 222
6:04	Honda Marysville	1	Hitachi-Zosen	2	F to R Door	Inland	--
10:35	CPC Grand Rapids	2	IHI	3*	Sedan to wagon rear dr.	National	UAW 730
11:56	CPC Marion	I	IHI	3*	LH to RH door	Bethlehem	UAW 977

* Includes stand-alone double-action press

wedged in the press and the die change had to be aborted while the crane came in to unload dies, pick up the sub plate and reverse the procedure after repairs were made.

But to show that the team's spirit hadn't been broken, it prompted us to time a second attempt. After it sped through a 10:04 die change, the team sat down to tell us that with a little modification to the booms, it felt that seven minute die changes were possible.

"We run 61 different parts on that line," one team member said. "And we do four die changes per shift. Every once and a while, things like that are going to bite you. Heck, that just means you've got to work harder together."

"Hey, we've got Browns and Steeler fans working together here," said another employee. "So if they can work together, this ain't nothing."

Renault Argentina

Renault Argentina's press plant was built by Kaiser Industries in the 1950s. Obviously it's not a new facility; nonetheless, the plant is tidy and well-organized. Even the safety lines on the floor are freshly painted in a gleaming yellow.

With the older-type presses being used, the press shop is fairly labor intensive. Each press is manually fed by two men. Panels are removed by automatic extractors.

When the die change begins five men push the conveyors between presses out of the way. Though the toggle has a moving bolster, the rest of the dies are tugged out of the presses with chains and an overhead crane. The crane moves each die behind a safety line, and the workers line it up with the safety line, then drop it down. It takes nearly four minutes to get the first die into the toggle, as they have to wait for the bolster to build up air pressure.

The team has a good work pace—hurried, but not frenzied. You can tell that the workers are pumped up for the Die Change Challenge. They showed up for their shift two hours early! The first team achieves a time of 15:47, the best yet.

The second shift is inspired by the excellent performance of the first shift, and they set out to beat them. Every movement is done a little quicker. And the anxiety level rises a notch. Sure enough, they achieve a time of 13:32.

The result is met with thunderous applause by the crowd of spectators who have gathered from other areas in the plant. The emotion is unbelievable. Caps are thrown in the air and the workers embrace one another. Their pride shows, not only because of the results of their hard work, but because Argentina has demonstrated it too can compete with the most advanced nations of the world.

Cadillac Grand Blanc

While other plants worked diligently to find a line that could be reduced to a two minute, pushbutton affair, Grand Blanc's "Cadillac Express" team went for chains, cranes and 592,370 pounds of dies. Even more incredible, the decision to do the four-press "V-Line" was made only one week earlier. And there was no practice—none!

Physically, the line poses a real challenge to quick die changes. Quarters are so close that when the automation is run out, it butts up tight against the adjoining line. And a fourteen-member die change team has to coordinate their moves pretty efficiently to stay out of each other's way.

The average time for changing this line was 5.3 hours in the previous month. But after making all the shut heights equal, installing a floating punch in the draw die and using a common skid between presses three and four, the team had turned in a quickest time of two hours and 15 minutes.

With that in mind, we were amazed when we started timing the actual die change. Team members manhandled 4000 pounds of chain, moving 94,000 pound dies sets with uncanny speed. And a cry of "HOSE! HOSE!" from the crowd averted disaster, as a ram nearly came down on a hydraulic line that was draped over the top of a die.

When number three press quit flat on the bottom, team members had to inch it up manually. And then when the first blanks were coming through, the automation dropped three panels.

Still, the first good panel was through in just 23:40, and the specta-

Continued on p. 33

MANUAL TANDEM LINES

TIME	TEAM	PEOPLE	TYPE	PRESSES	PANELS	STEEL	UNION
9:41	BOC Pittsburgh I	11	Danly	6	RH to LH fender	USX	UAW 544
10:04	BOC Pitt. II	10	Danly	6	LH to RH fender	USX	UAW 544
13:32	Renault Argtn. II	15	Bliss/USI Clearing	5	R-11 to R-9 door	Pro. Sid.	SMATA Cordoba
15:47	Renault Argtn. I	15	Bliss/USI Clearing	5	R-9 to R-11 door	Pro. Sid.	SMATA-Cordoba
23:40	Cad. Grand Blanc	14	Danly	4	Riv. to Eldo. roof	Armco	UAW 1292

SEMI-MANUAL TANDEM LINE

TIME	TEAM	PEOPLE	TYPE	PRESSES	PANELS	STEEL	UNION
10:47	Buick City	18	Danly	6	Buick to Olds 1/4 panel	LTV	UAW 599

tors erupted like they'd just won the lottery. "There's not much we can do to make it faster," one team member said. But one of the veterans of Grand Blanc's first die change smiled and said, "That's the same thing we used to say."

AUTOMATED TANDEM LINES

B-O-C Lansing

It's been three years since BOC's Lansing plant entered the Die Change Challenge. What an amazing transformation has taken place!

Back in 1988 it took 20 people over 8½ minutes to make a die change. But this year they did it completely automatic in only 2 minutes and 15 seconds, and won the 1991 Die Change Challenge.

Two fundamental changes took place to allow this dramatic improvement. First, the press line was upgraded with a programmable automatic de-stacker. After a pre-programmed number of blanks have been run through the line, it automatically goes through a die change with absolutely no input from a human being. Second, with the introduction of the 1992 N-cars, the Lansing Automotive Division reduced to five from seven the number of dies needed to stamp out a fender. Not only did this save GM millions of dollars in tooling costs, it drastically reduced die change time.

Interestingly, Lansing also assigned 10 hourly people to the N-car engineering group to give their input for the most effective tool design. "We always said that if they'd get us involved early enough, we'd help make tremendouos improvements," says Gary Watson, chairman of UAW Local 652.

All the improvements to the press line were done in-house by the people on the floor. Even so, everyone involved credit their teamwork, not their new technology, for their improvement. "I wondered if I'd ever see this day at General Motors. It's one of the brightest days in my 27 years at GM – how you've surprised management. The credit is all yours," Mike Camp, the plant manager, tells the team.

Hirotec Japan

Many automotive stamping operations make their own dies. But we only know of one that manufactures its own stamping presses and its own quick die change system. Because of this, we expected Hirotec, supplier of all of Mazda Japan's door assemblies (400,000 per month), to be somewhat of a stamping master. We were correct.

Hirotec is the first stamping shop in Japan to enter *AI's* Die Change Challenge. Observing a die set in their Hiroshima plant is as pleasurable as watching an expert chef prepare a special dish. There's absolutely no wasted motion during a Hirotec die set, so there's no wasted time. The results are consistently quick, clean die changes – 90 seconds each, on average, and many times per shift.

When we visited, the hot time to beat was 83 seconds. Yet no one in the plant seemed concerned, as this was no aberration. The actual die change we recorded went like this:

At the lead end of the press line, one team member moved the sheetloader, pushed the button to start the die change and move the front die carts. His two partners, stationed at the center and end of the line, moved the gates and conveyors between presses 2, 3, and 4 aside, then pushed buttons to start the movement of their respective die carts. Dies changed, each operator moved his conveyors back, closed the gates, and the new panels were on their way.

It was all over in 87.5 seconds.

There are keys to such world-class times. One is that Hirotec designs its dies to be absolutely as small as possible.

More importantly, the company gives utmost priority to thorough preparation and attention to detail – "standardization of all things involved in the die set," noted stamping manager Mr. Aseada – plus teamwork and the company's HQDC system. (For more on HQDC and Hirotec, see page 46 in this issue.)

By this he means locating each mating surface – cushion pins, automatic clamps, bolsters, conveyors, air couplers, microswitches, sensors – with surgical precision, so they mate up perfectly during the die set. At Hirotec, this is a source of pride.

But Aseada and the Hirotec stamping teams say they are capable of much quicker die changes – in the 40-second range. They're already designing new equipment for this, including faster die carts, new software and fewer conveyors between presses.

It's actually not necessary to set dies in 40 seconds – unless the customer needs it. But process improvement is a daily ritual at Hirotec.

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AUTOMATED TANDEM LINES

TIME	TEAM	PEOPLE	TYPE	PRESSES	PANELS	STEEL	UNION
1:27	Hirotec Japan	3	Hirotec	4	LH to RH door	NKK + Nippon	--
2:15	BOC Lansing	1	Danly	5	LH to RH fender	Inland	UAW 652
2:19	Ford Hermosillo	4	Komatsu	4	LH to RH door	Kawasaki	Sin. Nac.
2:38	Honda Marysville	3	Danly	3	Inner to outer hood	Inland	--
6:07	Chrysler Twinsburg	4	Schuler	6	C-car door to Y-car	Inland	UAW 122
6:22	Honda Alliston	1	IHI	4	US to CN body side	--	--
17:46	Chry. Twinsburg	4	Schuler	5	LH to RH door	Nippon	UAW 122

Honda Alliston

The folks at Honda's plant in Alliston, Ontario in Canada have been using the Die Change Challenge to help improve their stamping operations. And the results really show.

Last year they concentrated on getting process improvements, while this year they worked on improving their equipment and software. Specifically, they reduced the amount of equipment that has to be changed, and rewrote their software to so that it runs in sequential instead of overlapping sequences. They also involved a whole new group of people in their preparation to get more associates involved in the competition.

A year ago Alliston used four people on its die change team. But with the new improvements, the new team only consisted of one person, Russ Pelten, who proved he truly knows how his press works.

Everything ran perfectly smooth as the die change got started, but about halfway into it, the automation on one of the presses balked. In a flash, Pelten immediately figured out what was wrong. He hands were a blur as he flipped switches and pushed buttons, and manually ran the press through its operation.

As it turned out, the die change was slower than the Honda people had hoped for. Nonetheless, by reducing the number of people needed to do the die change, they achieved a whopping 67% productivity improvement over last year.

Honda Marysville II

A phrase we hear over and over in our travels is: "I don't how we could improve on what we just did." We heard it from last year's team on Honda's B-line. And since we didn't believe it then, we weren't surprised to see Honda take a quantum leap in reducing its number of employee-minutes for this year's effort.

The trick was to upgrade B-Line's manual clamps to automatic. And with that one modification, Honda reduced its manpower from six to three. The team was also quick to point out that the clamps have made routine die changes safer. That's because there's less people involved.

For the sake of our challenge, B-Line changed from the Accord hood stiffener to the hood outer – the fastest part-to-part the line runs. In more complicated changes, the line usually has five or six people, and a die change of about eight minutes is typical.

But when the official clock started, the operation flowed much faster. The three members of the die change team had their moves carefully timed and there was no wasted motion or waiting for another team member to finish their job. As the safety gates closed and the first panel moved in, the team wore a look of confidence.

The first panel came out in 2:36 – a new record for this line. And though the crowd that had gathered was pretty subdued in comparison to other plants, all wore that Honda-proud smile that said "Relax, we do this all the time."

Ford Hermosillo

From the moment we arrived at Ford's Hermosillo plant (220 miles south of Tucson, AZ) we could see the die change team was anxious. Problems had developed with the #3 press on the previous shift, and everyone was concerned that the press might act up again and hamper their efforts.

Happily, the maintenance crew had identified and eliminated the cause of the problem because this well-choreographed group of workers went to turn in their best time ever.

Not only did the team accomplish this die change with fewer people (four people this year vs. five people last year), they managed to knock more than half a minute off last year's time. This gave them a 64% productivity improvement!

They were able to reduce the number of people on the team by choosing similar-type panels that did not require a change of tooling (extractors). Then, through better planning and organization, they were able to reduce their time. For example, when the operator on press #1 finishes his tasks, he moves down the line to assist the next operator.

Interestingly, the team feels it can do even better next year. "We know we can go under the two-minute mark," a confident operator assures us.

Chrysler Twinsburg I

You'd never guess the automotive industry is in a slump by visiting Chrysler's Twinsburg Stamping plant. This place is *busy*. Twinsburg's 29 major stamping lines (20 of them dedicated to doors) have been running 23 load-hours a day, including preventive maintenance (PM). In a typical shift, the two press lines we observed change dies three times and run eight different parts – 16,300 pieces every day.

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That's full-tilt production in anybody's ledger.

In addition to stamping and assembling door panels for most Chrysler cars and large vans, Twinsburg stamps minivan dash panels, A-car bodyside apertures and front fenders. Twinsburg is also doing some die construction ('93 Dodge T300 pickup).

But how quick are these guys on die sets? Last year Twinsburg absolutely smoked our Tandem Press category, with a blistering 2:35 set. That's a tough time to beat, and both teams entered knew it. In fact, they'd been in at 4 AM to practice on the day *Automotive Industries* arrived.

Schuler Line #2 was up first. Within 90 seconds after our stopwatch clicked on, the T-burg boys looked like they might again crack the 3:00 mark – no sweat, smooth as silk. But an inexpensive coupling on Press 1 came loose, stretching Line #2's die change time to a still-commendable 6:07.

On deck was Schuler Line #1, entered at the last moment with untried tooling – "cold turkey," as a team member described it. When the stopwatch finally stopped at 17:46, the team had given their best shot. But it was clear that Line #1 needed to be set up like Line #2, in order to be in the hunt.

The ultra-competitive Twinsburgers are already looking at solutions: Shut heights were off by as much as six inches between dies, and would have to be standardized. So would handler settings. Automation software could be tweaked. Speed of bolsters, clamps and lift cylinders could be boosted by fitting larger hydraulic lines and perhaps even adding a separate hydraulic system for the clamps.

Both Twinsburg teams are confident about doing sub-2:00 die sets on their lines next year.

B-O-C Buick City

It was Friday the 13th. It was the first time this line was entered in the Die Change Challenge. It was all-new automation. And there were only three days to practice.

No problem. These guys are seasoned pros.

As the last panel moved through the presses, the 18-man die change team moved right in behind it to break them down. But when it got to the automatic extractor on the last press, there was a long pause before it moved in to be stamped.

Officially, the word is that the last press gate was opened too soon and it shut everything down. And even though we were watching the first presses being completed (without benefit of our watch running) we were assured that it offered no advantage and wasn't planned. Hmmmm.

When the last panel finally hit the conveyor, the die change was actually well underway. Unlike last year's line, the automation had to be run out to make the change, so it was expected that it would take a bit more time. In practice the team had managed a best effort of 14:00. When our clocks stopped at 10:47, team members were pleasantly surprised, especially the member who had 10:47 in the betting pool.

Could it have been faster? Well, the team says that with a little practice they could cut the number of people considerably. And when they get the automation working the way they want...well...just wait until next year.

THE RESULTS

We have three basic categories in the Die Change Challenge: transfer lines, manual tandem lines and automated tandem lines.

MOST IMPROVED TEAMS
(% IMPROVEMENT IN EMPLOYEE-MINUTES)

TEAM	1991	1990	1989
1. B-O-C Lansing	98%*	--	--
2. Ford Walton Hills	70%	--	--
3. Honda Alliston	67%	--	--
4. Ford Hermosillo	64%	22%	--
5. Honda Marysville II	54%	12.7%	12.4%
6. Honda Marysville I	9.5%	--	--

*Compared to 1988

Yet even with these different categories, we don't have an exact comparison between teams because there are so many different kinds of press lines.

That's why we've included the charts on each category. This will allow you to factor in the variables, such as the number of bolsters, or presses that were involved.

Now for the results.

Transfer Line Category: Ford's Walton Hills showed that it is not only the fastest, it is the most efficient.

Manual Tandem Line Category: B-O-C's Pittsburgh team was both fastest and most efficient.

Automated Tandem Line Category: B-O-C's Lansing team showed that it was the most efficient.

Fastest Team: Hirotec's entry from Hiroshima, Japan. These guys are really good. When the object is to change from making one set of parts to another, Hirotec has shown it is the best in the world.

Overall Winner: B-O-C's Lansing team took first place in *Automotive Industries'* 1991 Die Change Challenge. Not only was the Lansing team the most efficient, since 1988 the team has achieved an amazing 98% improvement in efficiency.

In closing, it's important to remember that really all the entrants in the competition were winners. These 23 teams represent the best die change operators in the automotive industry. AI

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AUTOMOTIVE INDUSTRIES

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THE SECOND COMING OF SLER

Chrysler chairman Lee Iacocca shifts focus to internal structure. Page 18.

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Electric Shock!

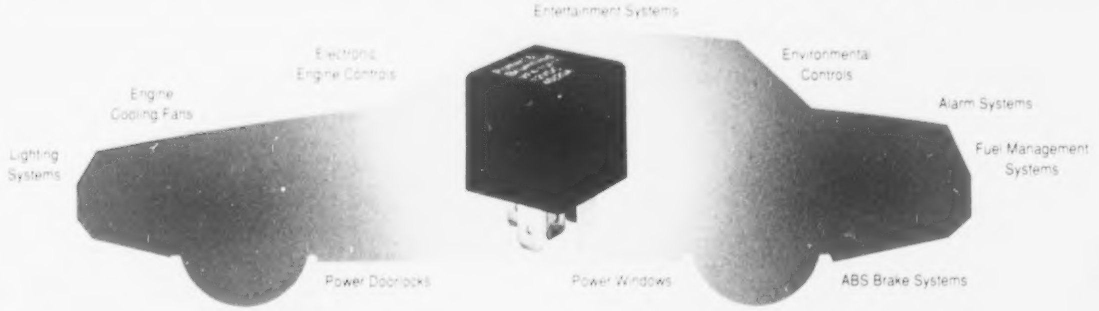
The recent Tokyo Auto Show touted an "electric vehicle showcase" that probably did more harm to the technology than good. Huddled off in a makeshift tent were gathered mostly **undeveloped, impractical examples of electric cars**. Some vehicles had 40 mph top speeds, some had a range of 50-60 miles and some were cobbled together with duct tape (honest!). Those vehicles that managed marginally acceptable range or performance, relied on environmentally questionable nickel cadmium batteries. Meanwhile, back in the States, the Automotive Battery Consortium and the Department of Energy have announced a joint $250 million R&D program to achieve a battery breakthrough.

Continental Divide

In the US, 1990 sales of diesel-powered vehicles remained pretty much as they always have – slow and incremental. But across the Atlantic, **Europeans bought oil-burners at record levels**. A total of 1,879,566 were sold Europe-wide, and in France and Belgium they accounted for one-third of total sales. By ranking, the most popular models in Europe are:

Model	1990 sales
1. VW Golf	131,588
2. Peugeot 405	116,157
3. Peugeot 205	102,110
4. Renault 21	97,042
5. Citroen BX	88,292
6. Renault 19	79,779
7. Mercedes-Benz W124	77,016
8. Peugeot 309	68,889
9. Ford Escort	63,190
10. GM Kadett/Astra	61,021

P&B relays handle tough automotive switching problems



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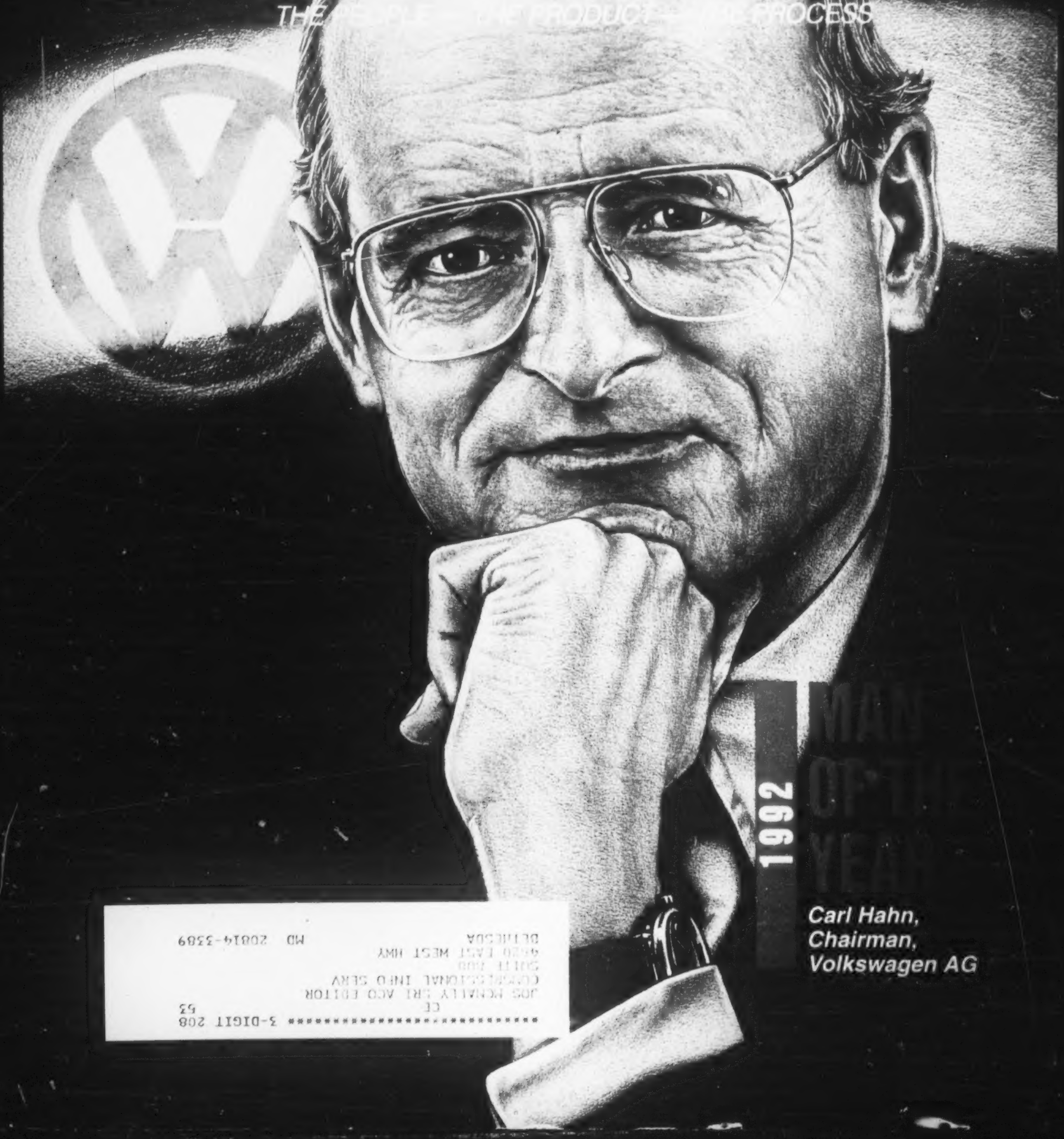

1992 MAN OF THE YEAR

Carl Hahn, Chairman, Volkswagen AG

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Dr. Carl Hahn is the architect of wholesale change at VW. Page 40. Cover portrait by Randy Hamblin

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by GERRY KOBE

ELECTRIC CAR UPDATE

California's new emission laws force automakers to re-invent the automobile.

The Federal Clean Air Act of 1990 and the latest regulations issued by the California Air Resources Board (CARB) proves the wisdom of an old saying: "Don't get too comfortable." For automakers, the new laws will tax R&D spending to the limit, dividing efforts between lower-polluting alternate-fuel vehicles, Low-Emissions Vehicles (LEVs), Ultra Low-Emissions Vehicles (ULEVs) and the ultimate in earth-conscious transportation, Zero-Emissions Vehicles (ZEVs).

CARB's ruling requires mandatory production of ZEVs, beginning with 2% of California's annual car sales in 1998, 5% in 2001, and rising to 10% by 2003. Automakers that sell fewer than 3000 units annually in the state are exempt from the law. Mid-volume manufacturers (3001-35,000 units annually) are exempt until 2003, but then must meet the 10% requirement.

CARB maintains that the law was necessary to support early efforts by automakers to produce electric models. And it based its decision on manufacturers' contentions that it requires a minimum 3000 units per year to make production of electrics feasible.

Meanwhile, a group of 12 Northeastern states have decided to copy California's new tougher standards—driving numbers even higher. Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania Rhode Island, Vermont and Virginia, along with Washington D.C., are already supporting the rules. In addition, decisions by Colorado, Louisiana, Oregon and Utah to adopt the standards are pending.

Combined registrations of California and the Northeast states represents 37% of the US car and light truck market. If all of the states considering the tighter standards decide to put them into effect, the number will jump to near 50%.

For automakers, ZEVs will be a key to survival.

At present there are two accepted meth-

Citroën Citela

PSA Peugeot Citroën has been involved in electric vehicle R&D for over 20 years. Most of the company's efforts have involved conversion of conventional automobiles to electric for commercial fleet use. To that end, it hopes to sell 50,000 converted vehicles in MY 1995.

But the latest revolution from Citroën is the completely recyclable, electric-powered three-seat prototype Citela (City Electric Automobile).

Citela is based on a modular design that consists of a rigid rolling platform with a removable shell. The steel spaceframe is uniquely designed to take advantage of the structural integrity of the nickel-cadmium battery pack. It actually incorporates the pack to reduce flex and strengthen overall platform rigidity.

The car has interchangeable thermoplastic body panels that can convert it from coupe to small utility vehicle. All panels are easily removed to make conversions simple and promote ease of recycling.

Citroën intends the Citela to be durable enough for long-term use. The platform spec calls for one million kilometer durability, and batteries must exhibit a 10-year life. The car has a claimed top speed of 68 mph, and has a 68-mile range at an average 56 mph.

PSA Peugeot Citroën is currently participating in a government-sponsored program in France to evaluate the daily use of electric vehicles in an urban environment. In 1993, the Electric Company of France will equip the city of La Rochelle with public terminals where electric cars can be recharged. PSA Peugeot Citroën will provide 50 vehicles to select residents for evaluation.

Citroën Citela is designed for long-term use and ease of recycling.

ods of producing a ZEV vehicle—hydrogen and electric power. Hydrogen vehicles represent the most "familiar" alternative for consumers, but issues of safety, durability, driveability and packaging present bigger hurdles than can likely be cleared by the 1998 deadline.

The challenge in electric vehicles is small by comparison. The single biggest drawback lies in the development of a battery pack that will provide adequate range and quick recharge capabilities. And that issue is being jointly addressed by major automakers, battery manufacturers, utility companies, The Electric Power Research Institute (EPRI) and the Department of Energy (DOE).

The United States Advanced Battery Consortium (USABC) was established little more than one year ago, and has quickly established funding with the help of the DOE. The Big Three are business partners in the consortium, with the Electric Power Research Institute and DOE acting as non-business associates.

Last October, the DOE matched the consortium's funding levels on a one-to-one basis, placing the ABC's Phase One spending (through 1994) at $260 million. According to Roberta Nichols, Manager of Electric Vehicle External Associations for Ford and Secretary of the USABC, this is a major milestone in US automotive history. "This is the first time that government funding has happened with a goal of obtaining commercialization," says Nichols. "And it's a much bigger step away from [pure] research than any other relationship we've had previously. It will allow the technology to progress much faster than if any one of us had to do it

IMPLEMENTATION SCHEDULE FOR CARB STANDARDS

Model Year	TLEV .125	LEV .076	ULEV .040	ZEV .00	Fleet Avg. Standard
1996	20%				[illegible]
1997		25%	2%		.202
1998		48%	2%	2%	.157
1999		73%	2%	2%	.113
2000		96%	2%	2%	.073
2001		90%	5%	5%	.070
2002		85%	10%	5%	.068
2003		75%	15%	10%	[illegible]

Percentage requirements for ZEVs are mandatory

ESTIMATED ZEV VEHICLES REQUIRED BY CARB STANDARDS

Year	%	California and Northeast States	Pending States	Total ZEVs
1998	2	107,000	13,000	[illegible]
2001	5	268,000	33,000	301,000
2003	10	537,000	65,000	602,000

Ford Connecta

Making its world debut at the 1992 Detroit Auto Show, Connecta is Ford's concept vision of the 'family taxi' of the future. It features bucket seats for four, with two additional rear-facing seats that pop out of the rear cargo area floor. Front passenger seat is equipped with an integral child seat.

For ease of entry, the vehicle has two center-opening doors (with no B-pillar) on the passenger side. The driver's side has a large single door. Beneath the skin, Ford uses a 330 V three-phase AC drive motor that combines both forward motion and braking functions into one compact unit. The motor is linked to a single-speed direct-coupled transaxle.

An electronic control module converts voltage from DC to AC and also regulates power from conventional charging and regenerative braking inputs. Connecta is fully multiplexed with a microprocessor-based controller monitoring all critical vehicle functions.

Battery technology is sodium-sulfur which has twice the energy storage capacity of lead-acid. Ford claims the combination of high power and low weight enables this car to approach the performance of conventional gasoline-powered vehicles.

Ford says the Connecta can be fully recharged overnight using conventional household current. Special 220 V outlets could reduce charge time by 40%.

Ford Connecta has sodium-sulfur batteries with twice the energy storage capacity of lead-acid.

alone." Right now, Nichols expects lead-acid batteries to power the first electric vehicles (EVs), but many viable challengers are on the horizon. Nickel-cadmium batteries offer an energy-hungry quick-charge capability, but can't hold a complete charge unless fully discharged, thus affecting vehicle range.

Lithium batteries are also under study, but temperature variations affect their energy release and reliability. Francois Castaing, vp—engineering at Chrysler, says lithium batteries hold a lot of promise long-term, and by 1995 the technology should be available for automotive use. Properly incorporated into the design, Castaing says lithium batteries could extend range to 300 miles.

On the horizon, sodium-sulfur could become the battery of choice. Compact and energy dense, it could ease packaging problems.

However, sodium-sulfur's chemical reaction releases large amounts of heat, and would require a unique recycling structure. Expense is also a problem. As we went to press, the consortium was still negotiating contracts with a number of companies con-

Nissan FEV

In response to the allegations that electric vehicles are not practical because of lengthy recharge times, Nissan is touting the world's fastest battery charging system. It's found in Nissan's FEV (Future Electric Vehicle) and Nissan claims it can achieve a 40% charge in six minutes! In addition, a 100% charge takes only 15 minutes.

The secret lies in FEV's 23 Nickel-Cadmium batteries which are very thin and lightweight (444 lbs). By using thinner and stronger separators than conventional units, surface area is increased, heat dissipation is improved and generating efficiency enhanced. Advanced materials also reduce electrical resistance.

The drawback to Nissan's quick charge system is that it would require 440V inputs to achieve its quick charging time. To accomplish this, the company acknowledges the need for an infrastructure with recharger units in shopping malls, office complexes, dealerships, etc.

The FEV uses two 20-kW motors driving the front wheels. It has an aluminum alloy floor and plastic body panels. The car is equipped with airbags and uses a heat-pump style air conditioner.

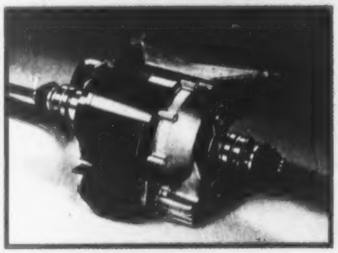
Nissan FEV boasts fastest charge time.

BMW E2

BMW's new E2 electric, which debuted at the 1992 L.A. Auto Show, is a larger, longer range version of the company's diminutive E1. BMW tailored the 2205-lb E2 toward Americans and American driving conditions. Its thermoplastic body, which rides on an extended E1 aluminum subframe, was styled by BMW's California studio, Designworks/USA.

The E2 carries more powerful batteries for a claimed 267-mile maximum range and 161-mile typical range. Claimed top speed is 75 mph, with 0-50 mph acceleration in 15.6 seconds. The E2 requires a 6 to 8 hour recharge.

Like all BMWs, the E2 is rear-wheel drive. Its electrons come from a large (over 450 lb) sodium-sulfur battery located underneath the rear seat. The battery powers a liquid-cooled, permanent magnet electric motor/differential designed and built by Unique Mobility Inc. of Englewood, CO.



Unique Mobility's permanent-magnet electric motor/differential is compact, liquid-cooled.

The compact (14-in. diameter), 32-kW traction drive motor features a fairly flat torque and power curve—111 lb-ft and 45 hp—and operates through a BMW-designed single-speed gear reduction. Unique Mobility also designed and manufactures the cars' electronic controllers, also liquid-cooled. The BMW-Unique Mobility partnership began at the 1990 Detroit SAE show, and the E1/E2 project started in January 1991. Since building 50 of its own electric vehicles ('ElecTreks') in the 1970s, Unique Mobility has specialized in the development of electric motors and hybrid-powered vehicles including buses and military equipment. The company's motor technology is jointly owned by Alcan Aluminum.

BMW E2 was styled by Designworks in California. Body is thermoplastic, some of it recycled material.

cerning 'best technology' for future-generation EVs.

This technology covers the entire vehicle, not just power systems.

Materials suppliers are proposing ultralightweight alternatives to plastic, steel and even aluminum. Carbon fiber is being widely considered, though breakthroughs in price and process would be needed for mass production.

Manufacturers of electrical components tout systems with low-draw characteristics. And power-and-signal distribution suppliers have developed low-resistance wiring and switchgear.

Glass that reduces solar load, tires with lower rolling resistance, LEDs, regenerative braking systems, heat pump technology, fiber optics and battery recharging systems are just a few of the technologies that are poised for explosive growth as electric vehicle production draws near.

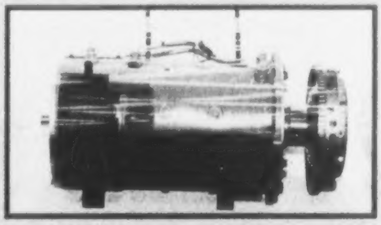
Of course, the USABC is reluctant to share the details of this research before negotiations with these companies are completed. And its refusal to admit Japanese manufacturers stems from the members' belief that the US has the lead in electric vehicles, and should work to maintain that competitive advantage.

On paper, the notion that the US has a technological edge in electrics has some basis in fact. Projects like GM's Impact are well along toward the goal of mass production. But the European countries, particularly the UK, have a great deal of practical experience in producing and fielding electric vehicles.

As of 1989, the UK had approximately

Dodge EPIC

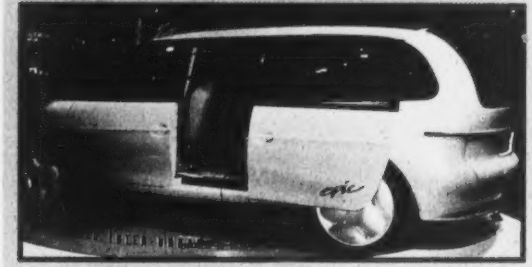
The Electric Powered Interurban Commuter (EPIC) is Chrysler's latest concept minivan. It utilizes the basic electric drivetrain from the company's TEVan program, a feasibility study which Chrysler vp of engineering Francois Castaing claims will be test marketed before the 1995 model year. "We are racing with the California 1998 regulations," Castaing says.


Epic DC drive motor.

Like the TEVan, EPIC's 'juice' comes from a 180V/200 amp-hour nickel-iron battery pack mounted within the floorpan. The 1800-lb pack features an automatic watering system, good for three months between refills. If EPIC were in production today, the nickel-iron battery pack would cost Chrysler approximately $10,000, versus about $2000 for a comparable lead-acid battery pack, says Bob Davis, executive engineer for vehicle engineering.

Chrysler worked jointly with General Electric in developing EPIC's 40-kW (56-hp) electric DC drive motor. It's a modified GE industrial unit, air/oil-cooled, which runs through a 2:1 reduction gear and separate clutch and two-speed automatic transaxle. The motor is set up to double as a generator during vehicle braking, giving EPIC regenerative braking. According to Davis, in a typical city driving cycle it will recover about 15% of electric power, says separate electric motor runs the vehicle's A/C system.

After traveling 120 miles (the SAE J227a C-cycle), the vehicle requires an eight-hour recharge on a residential-type 220V circuit. Top speed is a claimed 65 mph.


Dodge Epic uses nickel-iron battery technology. Current cost is five times lead-acid batteries.

TEPCO IZA

The IZA is a joint effort between Tokyo Electric Power Co. Inc. (TEPCO) and Tokyo R&D Co. Ltd. And if all claims for the vehicle are true, it represents Japan's best threat to GM's Impact.

IZA is a huge car by electric vehicle standards, measuring approximately 192 in. x 70 in. x 50 in., and weighing a hefty 3460 lbs. It seats four people comfortably.

The car features wheel-in-motor technology that puts a DC brushless motor at each front wheel. Claimed torque is a staggering 307 lb-ft. Power comes from a 288 V NiCad battery pack, with a lead-acid auxiliary battery to run accessories. Regenerative braking con serves power.

The most incredible aspect of the IZA is performance. Claimed acceleration for a standing quarter mile is about 18 seconds flat. The manufacturer claims a top speed of nearly 110 mph. Range on a fully charged set of batteries is said to exceed 340 miles at a constant 25 mph.

IZA's batteries will charge fully with an eight-hour charge cycle. Voltage to the charging unit is 200V at 50 amps.

IZA's performance is best effort yet from Japan.

Continued From Page 81

25,000 electrics on the road.

And many private companies in that country are accelerating their work on battery technology, particularly sodium-sulfur.

Japan has a small base of electric vehicles in operation (about 4000 in 1990), but has recently given priority status to developing more sophisticated cars. Japanese automakers are leaning toward nickel-cadmium batteries as a solution to quick charge and extended range.

Recyclability, though very much an issue with NiCad, is one the manufacturers feel they can solve before ZEVs are legislated into existence.

But many questions remain unanswered. Electric vehicles will be more expensive and less reliable than gasoline or alt-fuel vehicles.

And while government regulations may mandate 10% of the market by 2003, it's doubtful that consumers will willingly pay more money for a less versatile and less proven vehicle.

There is also a question among power companies that they will be able to meet the demand created by electric vehicles.

If additional powerplants have to be constructed, they will have to be clean.

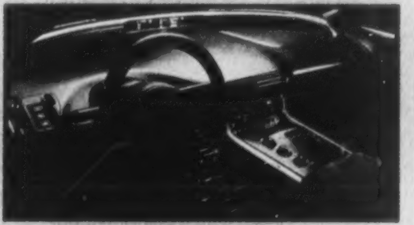
GM Impact

Impact's degree of development puts it well ahead of the pack in terms of being production-ready. But GM is still making changes to the fundamental vehicle.

Recent improvements made to Impact's inverter have boosted reliability exponentially. And GM is said to be testing a version of Impact that uses a single motor instead of one at each front wheel. The single motor is in response to project engineers having problems synchronizing output of two motors, which creates a torque-steer effect.

A four-door version of Impact is also reported to be in the works, but on a different chassis than the coupe.

Sources close to the project say that power for the second-generation Impact will likely be lithium batteries, and not NiCad as originally planned. They also hint that Impact will be exported in its second year, and that provisions for right-hand drive are built into the car.



Impact interior is designed to convey 'electric' theme.

Impact has undergone more testing than any proposed electric vehicle.

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Continued From Page 83

And given current sentiments toward nuclear power, the solution may be impossible to achieve.

Still, electric vehicles represent an opportunity for US automakers to disrupt the momentum of its Japanese competition.

And that factor is reason enough for the Big Three to show very little resistance to California's laws.

To domestic manufacturers, ZEVs mean a one-time shot at leveling the playing field with Japan. Given that, electric vehicles are going to happen—ready or not. AI

Automotive Industries *staff members* ***John McElroy, editor-in chief; Lindsay Brooke, executive editor;*** *and* ***Christopher Sawyer, senior editor*** *contributed to this article.*

Ford Ecostar

Ecostar shares the same mechanicals with Ford's Connecta, but this ZEV already has a buyer. Ford has entered into an agreement with Detroit Edison to supply Ecostars to the utility beginning in early 1993.

Alan Gilmour, executive vp and president of Ford Automotive Group says, "Ecostars will be driven and used in real working environments for several years before we will be satisfied enough to make them available for sale. We are not going to put Ford vehicles on public sale until they have undergone durability and operational testing, and we are certain they meet quality and customer satisfaction standards."

Detroit Edison

Ford's Ecostar will be tested by Detroit Edison Co. in 1993.

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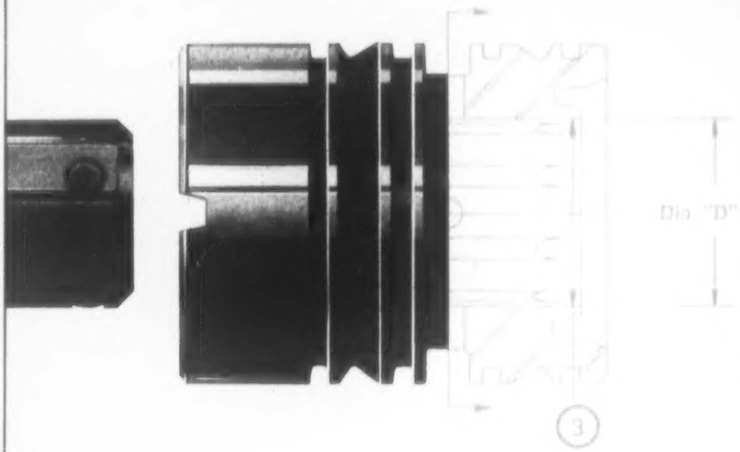

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IVHS

intelligent vehicle highway systems

An American's Tour Of Japanese IVHS

Japan will be the first nation to undertake widescale deployment of advanced driver information systems.

by JIM HAUGEN

This column is about a recent report entitled "An American Observation of IVHS in Japan" by Bob Ervin of The University of Michigan Transportation Research Institute (UMTRI). Ervin was part of a study mission to Japan in March of 1991. He was so impressed by what he saw he decided to document his findings in a formal report.

The importance of his report lies not just in his important personal conclusions, but also in his description of Japanese activities and the reasons behind their IVHS commitment. Especially insightful in his explanation of the forces supporting their commitment. He calls these "the 7 C's":

Congestion—Average vehicle speeds below 10 mph prevail through much of the daytime, even on expressways.

Conditioning—The Japanese government has 20 years of progress behind it in providing motorist information services, so motorists have come to expect continuing improvement.

Centralization—National highway construction and national traffic control are supplied by the Ministry of Construction and the National Police Agency, respectively.

Collaboration—Joint government/industry work in the IVHS area has been ongoing since 1973, with coordination by the Ministry of International Trade and Industry (MITI).

Customers—Executive buyers, who simply take "the full option package" in car purchases, provide an early market for automobile navigation systems, sparking industry competition.

Continuity—Their IVHS programs have been underway for almost 20 years, giving government and industry the opportunity to "learn by doing."

Cash—Japanese right-of-way is to expensive that stretching the serviceability of roadways through IVHS makes strong economic sense, so money is readily available.

The accompanying table, taken from the report, illustrates the importance of IVHS to the Japanese by comparing its road system to that of the US As shown, the Japanese road system is much less extensive. Even more important, this road network is distributed over a land area that's only 4% of the US, but serves a population half the size of the US.

Comparison of the Japanese and US Road Systems

Road Type	Length of Road Systems in Japan Total Miles	Length of Road Systems in the US Total Miles	Length Ratios Japan/US
Expressways	2,700	45,000	[illegible]
Primary Highways	29,000	259,000	11%
Prefecture (State)	80,000	49,000	[illegible]
Local (County & City)	575,000	3,073,000	19%
Total	**686,700**	**3,876,000**	18%

(figures as of 1988)

In addition, traffic volume in Japan has tripled since 1970. US traffic volumes in the corresponding period have grown by a factor of 19. Japanese traffic fatalities in 1970 were also six or seven times the US rate, calling for drastic improvements in traffic control.

Their response to these problems has been to deploy the world's most extensive system of computer-controlled traffic signals at intersections. Some 411,000 intersections are currently under computer control. Groups of intersections are under the central command of sophisticated central traffic control centers which now exceed 160. An aggressive US Advanced Traffic Management System (ATMS) IVHS program might approach such numbers in the next 20 years.

The Japanese have also pursued a series of important Advanced Driver Information Systems (ADIS) programs with acronyms CACS, RACS, AMTICS and VICS. These programs have led the government to the verge of deployment of a national driver information system. However, they

Continued on Page 118

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IVHS

Continued From Page 117

are now faced with significant deployment issues which will also arise in the US in the future. What is the best technology to standardize? Will a large number of users arise to buy such systems. How do you finance the roadside infrastructure required?

During 1991 MITI created an organization called the Association of Electronic Technology for Automobile Traffic and Driving. This organization has a 57-company membership and is pursuing a program called Super Smart Vehicle System (SSVS). SSVS is looking at ways to provide unusual levels of control assistance to drivers and covers similar ground to the US Advanced Vehicle Control System (AVCS) effort.

> *Because of the unique qualities of the needs of the Japanese road network, will the experience have only modest value in transferring elsewhere?*

Due to the lack of tort liability concerns in Japan, they are expected to have a much easier time in implementing SSVS based safety systems with the public. Toyota is cited in the report as predicting that IVHS based safety systems will be in use in Japan by 1995, much faster than expected in the US.

Ervin concludes by raising the issue of transference of Japanese technology to the US environment. Because of the unique qualities of the needs of the Japanese road network, will the experience have only modest value in transferring elsewhere? Or will the knowledge gained be sufficiently generic that the Japanese applications work will provide a basis for worldwide IVHS leadership? Some good challenges to think about as we consider how aggressive the US should be in its IVHS efforts. *AI*

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Volume 172, No. 3 March 1992

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GM's 100 mpg Ultralite is a rolling high-tech classroom with lots of lessons inside. Cover Photography: General Motors

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Europe's Changing Market

Unified Germany key to 1991 sales increase.

The good news is that new car demand in Europe for MY91 was a record for the seventh successive year. At over 13.51 million units sold, the total was fractionally higher than the previous year. The bad news was that Europe's bottom line was almost entirely sustained by Germany, the region's largest national market. Potential customers in the rest of Europe stayed home in their droves.

The consumer boom created by the collapse of communism, and subsequent German unification, contributed an additional 917,000 sales last year. Germany finished the year with nearly 4.2 million vehicle sales, roughly half again as many as 1989 figures.

But consumer confidence in the rest of Europe failed to match that of Germany. Concerns about national economies, high interest rates and increasing unemployment resulted in the next four largest markets—Italy, France, Britain, and Spain—dropping 825,000 units between them.

Automakers make more than 80% of their European new car sales in these five markets. They therefore set the overall European pattern, whatever the boom (Greece) or bust (Finland) elsewhere.

Unquestionably, the downfall of communism underpinned last year's auto industry performance. It provided an unexpected boost in what would have been a grim year. Even so, layoffs and job cuts were common across much of Europe. But Germany's unification spree was a one-off, unlikely to be repeated. Automakers are developing sales forces in other former communist countries, but progress will be slower and more painful.

The German experience helps explain why the Volkswagen Group, Ford of Europe and General Motors-Europe—all with strong German bases—recorded record sales. It also explains why VW strengthened its position as Europe's leading automaker, while that of second-place Fiat weakened Not that other automakers were left out by German car-lust. The French, Italian and Spanish—faced with sluggish domestic demand—were quick to spot the opportunity. Starting from relatively small bases, their share gains were impressive.

Another clear trend was the increasing fluidity of national market shares. The pattern is likely to accelerate as traditional borders are dismantled under the terms of the single European market, which becomes reality in '92. Some examples:

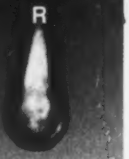
Renault and Peugeot of France and Spain's Seat did well in Germany last year, while all German-based groups except Ford slipped back, unable to meet demand. At the same time, Renault lost additional share in France, while Ford and GM's Opel made advances. In Italy, where Fiat lost a large chunk of the market, the gainers were importers like Ford, Renault and Opel. Peugeot improved in Britain, while Ford and GM's Vauxhall fell back. The other notable advance was made by the Japanese group, whose 12.3% (nearly 1.67 million units) included share gains in every national market except two: Germany, where Japan was not as nimble as the locals at exploiting the boom, and in Britain, where the leading maker, Nissan, was involved in an acrimonious legal dispute with the privately owned importer.

Nissan was again Europe's top Japanese make, as it has been for a couple of decades. It ended the year with 439,000 sales to Toyota's 361,000 and Mazda's 287,000. Honda was a distant fifth behind Mitsubishi.

The Nissan advantage over Toyota stems from its early inroads in Europe, particularly in Britain. The subsequent quotas imposed on Japanese cars then prevented other companies from catching up. Nissan's early groundwork prompted it to become the Japanese transplant pioneer in Europe. Now, with Japan's undertaking to continue European sales restraints for the rest of the century, Nissan looks set to hang on to its lead. It has laid down capacity to build 300,000 cars a year in Britain by 1993, while Toyota's and Honda's 100,000-unit transplants come on stream only at the end of this year. *AI*

EUROPE'S WINNERS AND LOSERS

Manufacturer	1991	1990
Volkswagen Group	[illegible]	[illegible]
Fiat Auto	[illegible]	[illegible]
Japan (all)	[illegible]	[illegible]
General Motors	[illegible]	[illegible]
Peugeot SA	[illegible]	[illegible]
Ford	[illegible]	[illegible]
Renault	[illegible]	[illegible]
Mercedes-Benz	[illegible]	[illegible]
BMW	[illegible]	[illegible]
Rover	[illegible]	[illegible]
Others	[illegible]	[illegible]
Volvo	[illegible]	234,000
Total	[illegible]	[illegible]



by LINDSAY BROOKE

FUELS' PARADE

Alternative-fueled vehicles will soon hit the streets in volume. But many developmental problems still nag engineers.

What will eventually replace gasoline as America's dominant motor fuel? As legislators nationwide trip over themselves to adopt California's stringent exhaust emissions laws, industry testing of potentially cleaner 'alternative' fuels proceeds in parallel with advanced emissions systems development. So far, a leading candidate to supplant 'good old gas' has yet to emerge—and one may not.

"Instead of having one fuel that replaces gasoline, there'll be a mix of fuels," predicts Scott Levy, vp of technical affairs at Clean Vehicle Technologies Co. (CVT), an independent alt-fuels and emissions program management firm based in Chicago. "Up until the 1996 model year, we're going to see a variety of fuels running in very low volumes of demonstration vehicles. At that point, it'll really open up."

Along with other emissions experts, Levy believes most automakers will then be selling two or three models of flexible fuel vehicles (FFV), designed to run on mixtures of methanol or ethanol alcohol and gasoline, at increased (over 100,000 unit) production levels. He says that by the late '90s, compressed natural gas (CNG)-fueled vehicles will have emerged in similar volume.

Shortly after the year 2000, advances in battery and accessory technology may begin to make electric vehicles truly viable. Within that timeframe, the Motor Vehicle Manufacturers Association estimates that 25% of all US vehicle travel will be by FFVs. Ultimately, Levy says hydrogen may come into its own as a motor fuel, but not until roughly year 2025.

Gallons
M85

Behind the move to FFVs and alt-fueled vehicles in general are the Alternative Motor Fuels Act of 1988, which provides automakers with incentives (CAFE credits) to produce alt-fueled cars and trucks, beginning in 1993, and the Clean Fuel Fleet Program. AMFA requires the demonstration and testing of alternative fuels in a variety of vehicles. It encourages federal agencies (including the Department of Energy, General Services Administration, Department of Transportation and the EPA) to purchase, with incentives, these vehicles for testing and use in their fleets.

The Clean Fuels Fleet program established by the Clean Air Act of 1990 covers fleets of 10 or more vehicles that are, or are capable of, central fueling. The program begins in 1998 in the 22 smoggiest US metropolitan areas, unless cars meeting these standards are not being sold in California—then it begins in 2001. It mandates that 30% of new fleet purchases, phasing up to 70% and including some large truck fleets, must meet California low-emission vehicle (LEV) standards (see chart on p.28).

Currently, Chrysler, Ford, GM and to a lesser extent, the imports, are testing the following fuels in thousands of mainly fleet cars and trucks in the United States: the alcohol/gasoline blends M85 and E85 (containing 85% methanol or ethanol with 15% gasoline blended in to aid cold starting); CNG; liquified petroleum gas (LPG); reformulated gasolines and diesel.

Hydrogen power has not been explored as deeply by American automakers as it has by some German companies and by Mazda.

While much progress has been made with 'alt fuels,' many problems still nag engineers developing alt-fueled vehicles. Depending on which California emission law they're applied to, most alt fuels cause degrees of driveability and/or emissions glitches. And most of them require new, often costly emissions systems hardware for optimum operating performance.

Says Gary McCarbery, GM Powertrain's technical manager, alternative fuels, "Unfortunately, none of these fuels contain a magic 'silver bullet' that we know of."

Nevertheless, alt-fuel technologists are trying to keep pace with a firestorm of political and environmental mandates. As this is written, Massachusetts has voted to adopt the California standards along with 14 other states. To help keep you abreast of developments, *AI* presents the following alt-fuel update, based on interviews with powertrain engineers, emissions experts, and related EPA and independent data. [Please note that while electric vehicles are generally considered to be alt-fuel, we covered them in a separate feature last month.]

CALIFORNIA 'CLEAN CAR' PILOT PROGRAM

		No. of cars,	Tailpipe Standards		
	Year begins	light trucks	NMHC	CO	NOx
Phase I	1996	150,000	0.125	3.4	0.4
Phase II	2001	300,000+	0.075	3.4	0.2

Notes: ❑ California must adopt program to assure fuel availability; if it doesn't, EPA must. ❑ California can adopt its own vehicle control program instead of the pilot program. ❑ Other states may opt-in to the program. **Source: EPA**

Flexible Fuel Vehicles: Known as FFVs at Chrysler and Ford and VFVs (variable fuel vehicles) at GM, they can run on M85, gasoline, or any combination of the two. MVMA president Thomas Hanna says FFVs are especially important in a transition from gasoline-powered vehicles, because consumers will be more likely to consider new alt-fuel technologies if they know they can refuel with conventional gasoline when the M85 is not available. Hanna stresses that FFVs allow more time to develop the US refueling infrastructure. They also encourage fleet owners to use M85, as FFVs will be easier to sell once they exceed fleet mileage limits.

Chrysler will build 4500 methanol-flexible 1993 Plymouth Acclaim and Dodge Spirit models, 2000 for California fleet and retail sales and 2500 for the GSA, which is spending $31.5 million in fiscal 1992 to buy 3125 alt-fuel vehicles from Chrysler and GM. Chrysler is offering $2000 rebates on FFVs to fleet buyers.

According to Francois Castaing, vp of vehicle engineering, Chrysler is planning for production of up to 100,000 FFVs in 1994 and 1995.

Ford will build 2800 flex-fuel Tauruses later this year, mostly for California, according to Harvey Klein, manager of alternative fuels engineering planning for North American operations. The cars will provide further durability data in various climatic conditions.

Klein says Ford plans Taurus FFV volume production in the 1994 timeframe but he's unsure of what 'volume' will be, adding that there are currently over 100 incentive programs for fleet purchasing among the states and federal government. A year ago there were 44 programs.

GM built 20 VFV Corsicas in 1989, all for California. In 1991 it built 200 variable-fuel 3.1 L Luminas, all-set up for M85. "For 1992, we've offered to California and the rest of the US capability to build 4000 more," says Gary McCarbery. Among the imports, most of the Japanese companies, Volvo, VW and Mercedes-Benz are all running small FFV test fleets in the US.

Fuel sensors are key to FFVs. Chrysler's is detailed on page 52 of this issue. GM's was developed by the Powertrain division and AC Rochester. Both measure the capacitance of the fuel, determining the percentage of alcohol in vehicle. The GM sensor includes a read-out on the dashboard which counts down the methanol/gasoline percentages as the car runs low on fuel.

"The only reason you'll see FFVs sell in big numbers is to get CAFE credits," states CVT's Levy. "The manufacturers will make them to run well on gasoline and OK on methanol—and they figure most people are not going to put methanol in them anyway."

M85 and E85: Automakers are reluctant to get a straight M85 program going for the end of the decade because they want to see how the FFVs will sell. GM, for example, has no dedicated M85 vehicles planned for production because "we have a hard enough time selling variable fueled vehicles—people afraid they can't get fuel," says McCarbery.

But if the industry does go to dedicated M85, automakers could realize power and fuel economy increases of 5% to 10%, due to M85's capability to support compression ratios as high as 12:1 or 13:1.

Besides fuel injector size and fuel pump capacity doubling, piston architecture will change, engineers note, with 'dry' fuels such as methanol or CNG. Going to a higher piston height in the combustion chamber bumps up compression.

And moving the head-land area up (decreasing the gap space between the first piston ring and the piston crown) can yield much lower HC emissions. This can also be done with gasoline, but it's not as effective.

For dedicated alcohol-powered engines, M85 is currently the leading candidate, mainly due to economics. Taking into account that methanol's energy density is 45% lower than gasoline, the cost of methanol is on a gasoline equivalency with premium unleaded, particularly when the gasoline becomes the more expensive reformulated fuel in the next few years.

IMPLEMENTATION SCHEDULE FOR CARB STANDARDS

Model Year	TLEV .125	LEV .075	ULEV .040	ZEV .00	Fleet Avg. Standard
1996	20%				.225
1997		25%	2%		.202
1998		48%	2%	2%	.157
1999		73%	2%	2%	.113
2000		96%	2%	2%	.073
2001		90%	5%	5%	.070
2002		85%	10%	5%	.068
2003		75%	15%	10%	.062

Standards noted above are for NMHC—non-methane hydrocarbons in g/mi. Percentage requirements for ZEVs

California Air Research Board (CARB) is mandating the emissions-free vehicle through a progressively restrictive set of standards. TLEVs are Transitional Low Emissions Vehicles; LEVs are Low Emissions Vehicles and ULEVs are Ultra Low Emissions Vehicles. ZEVs are Zero Emissions Vehicles—technically, electric vehicles and possibly hydrogen-powered vehicles.

Both alcohols are somewhat corrosive and lack the lubricity of gasoline. They require stainless steel fuel tanks and Nylon 11 and 12 lines. Ethanol is slightly less corrosive than methanol. Durability has not been a major problem; between 1984-87, Ford's 27-car test fleet racked up over a million miles with no major fuel-related problems.

"We could go methanol or ethanol, but we want to find out what the ozone improvement factors are," says Ford's Klein. "Right now, we think methanol has a slight advantage. But it's an economic and infrastructure issue, one that the oil and chemical companies will have to work with us on."

This year, GM will supply 49 E85-powered vehicles to Illinois, Wisconsin and the US DOE. GM had orders for more, says McCarbery, but deliberately withheld them, turning down orders from Iowa and Missouri because the response to ethanol just wasn't encouraging compared to methanol.

The infrastructure is the sticking point with both fuels. California now has roughly 20 stations with M85 refueling capability, with near-term plans to grow to 50. But the effort in the other 49 states has hardly begun. The Detroit area has two M85 stations.

Reformulated Gasoline: Refined to eliminate many pollutants, reformulated gasoline doesn't have the problems of performance, range and consumer acceptance of other alt fuels, says the MVMA's Hanna. But Scott Levy of CVT doesn't consider reformulated gasoline to be a true alternative fuel.

"First, at best it can only yield about a 20% reduction in HC, and maybe a 10% reduction in NOx. Second, the more you try to put hardware on the vehicle to get those reductions, the less reductions you get. There's a ceiling there; you can only go so far. But with the other fuels, there are opportunities to squeeze more out as you increase the technology in the vehicle."

CLEAN AIR ACT AMENDMENTS OF 1990

1994:	■ 50% further reduction of exhaust emissions
2004-2006:	■ Represent a 99% reduction in HC from pre-control levels, 98% for CO, 95% for NOx
	■ Require doubled life of emission control equipment
	■ Require on-board diagnostics (OBD) and mandates longer warranties

Levy and other engineers believe the big gains with reformulated gasoline will come from close-coupled catalysts. And achieving a wide powerband necessitates variable valve timing and improved EGR. The latter, engineers say, is software-driven EGR that's a grade more powerful than Ford's current PCOMP system.

But the biggest emissions improvements on reformulated gasoline-powered vehicles will probably come not from add-on hardware, but from engine design changes. Included here are bottom-feed air-blast fuel injectors, which greatly improves fuel spray atomization. Such injectors are part of many current two-stroke engine programs.

"Now you can start injecting down in the low end, close to valve opening, without clogging up the port with raw fuel, which brings the HC and NOx way down," notes Levy. And variable valve timing will allow injection on an open valve with timing changed so you get high overlap at high rpm and low overlap at low rpm.

Another option for companies who do not choose to add the $250-$300 per unit cost of a VVT system, would be to stay with low valve overlap and change the injector timing, injecting closer to an opening valve at low rpm, to make up for some of the overlap, Levy explains.

Engine Controller Changes: Look for more powerful control algorithms to appear in 1993 on GM vehicles and in 1994-95 on Fords. Once engines include a mass airflow sensor, there's a lot more that can be done in terms of software strategies.

But limited compression ratios and combustion efficiencies can limit gains here. So improvements to combustion chamber design and induction

systems (split-port cylinder heads by the mid-'90s) may be needed to match the new controller capabilities, variable valve and injection timing, etc. Again, it's the old 'no free lunch' syndrome.

Compressed Natural Gas: CNG allows compression ratios as high as 12:1, for more power, but its big problem is NOx.

CNG has been chosen for light trucks and some large rwd cars be-

ALT-FUEL VEHICLE TECHNOLOGY CAPABILITY SUMMARY FOR LIGHT DUTY VEHICLES

TYPE OF TECHNOLOGY	EXPECTED EMISSIONS CAPABILITY	CURRENT DEVELOP-MENT	CURRENT PERCENT DEVELOP.	MARKET ENTRY EST. YEAR	UNIQUE SYSTEMS HARDWARE ASSOCIATED WITH TECHNOLOGY [1]	FUEL ECON. COMPARED TO BASE [1]	EST. FIXED COST PENAL. (ADVTG) [1]	COMMENTS
Reformulated Gasoline Vehicles (RFGVs)	TLEV	Yes	95%	1994	EEP, MDIS, ICCC, IEGR	Same	$115	Improved cold operations emissions
	LEV	Yes	65%	1996/7	Same as TLEV plus ABI, IPH, EDI, VVT	(0.3) mpg	$415	Lower engine out emissions, improved catalyst efficiency
	ULEV	Yes	35%	1998/9	Same as LEV plus EMC, EHC	(0.3-0.5) mpg	$600	50K durability not yet attained for LEV & ULEV
FFVs On Blends Of M85 or E85 and Gasoline	TLEV	Yes	85%	1994/5	Same as TLEV RFGV plus UFSM, CSS, EDI, ACS	(9-12) mpg	$630	Fuel operating cost penalty of $0.30/gal, 30% decline in NMOG
	LEV	Yes	60%	1997/8 [3]	Same as TLEV FFV plus ICL, engine design optimization	(6-10) mpg	$680	Optimized for M85/E85 operation, another 10% decline in NMOG
Dedicated M85 or E85 Vehicles	LEV	Yes	65%	1997/8 [3]	Same as TLEV FFV plus ICL, engine design opt. eliminate ASC	(6-10) mpg	$590	Emissions durability better than FFV. Lower FFV. Fleet compst emission
	ULEV	No	0%	2003 [3]	Same as DM85/E85 LEV plus VVT, ABI	N/A	$760	50K durability not yet attained for LEV/ULEV DM85/DE85/FEV
Dedicated CNG Vehicles	'LEV	Yes	35%	1995/6	EDO, HPVS, CLFC, MCS, IGER, high-pressure fuel delivery system	+5 mpg	$1690	Fuel operating cost less compared to gasoline. 50K LEV/ULEV not attained.
	ULEV	Yes	10%	1998/9	Same as LEV CNG plus ICL, LHPVS, VVT, ICCC, FCC	+7 mpg	$1390	Low-cost/light-weight fuel storage allows for higher sales volume
Dedicated LPG Vehicles	TLEV	Yes (truck)	75%	1995/6	CLFC, HPFT, IEGR, ICL, EDO, medium-pressure fuel delivery system	+2 mpg	$(75)	Poor cold ambient temp. engine warm-up
	LEV	No	0%	N/A	Same as TLEV LPG plus EEP, MDIS, ICL, VVT, improved CLFC	N/A	$385	LEV emissions levels not yet attained
	ULEV	No	0%	N/A	N/A	N/A	N/A	Currently not considered feasible with known technology
Clean Diesel Vehicle	TLEV	Yes	55%	1994/5	IDI Diesel engine with EFI, IEGR, PT, and exhaust catalyst	+8 to 10 mpg	$660	Emissions durability better than FFV. Lower FFV. Fleet Compst. emission
	LFV	Yes	30%	1996/7	DI Diesel engine, EFI, VVT, IEGR, PT, LCIE & exhaust catalyst	+8 to 10 mpg	$1235	Fuel infrastructure in place, fuel oprtns. costs less than gasoline
Hydrogen Combustion Vehicle	ULEV	Yes	5%	2005/10	Hydrogen burn IC engine. High pressure fuel storage and fuel delivery system	(-15-20) mpg	N/A	Mainly being persued in Europe. Main emission is H_2O, Fuel costs, safety and system currently extremely cost-prohibitive
	ZEV	?	?	2010?	N/A	?	N/A	

Abbreviation of Definitions

ABI	Air Blast Fuel Injectors	EHC	Electrically Heated Catalyst	IPH	Intake Port Electric Heater
ASC	Alcohol Composition Sensor	EMC	Engine Mounted Catalysts	LCIE	Low Friction/Compression Ignition Engine
CCS	Cold Start System	FCC	Fuel Composition Compensation	LHPVS	Light Weight HPVS
CLFC	Closed Loop Accurate Fuel Control	HPFT	High Pressure Fuel Tank	MCS	Methane Catalyst System
DI	Direct Injection Diesel	HPVS	High Pressure Vessel Storage	MDIS	Multifire Distributorless Ignition
EDI	Engine Design Improvements	ICCC	Improved Close Coupled Catalyst	PT	Particulate Traps
EDO	Engine Design Optimization	ICL	Increased Catalyst Loading	UFSM	Upgraded Fuel System Materials
EEP	Enhanced Engine Processor	IEGR	Improved EGR	VVT	Variable Valve Timing
EFI	Electronic Fuel Injection	IDI	Indirect Injection Diesel		

Source: Clean Vehicle Technologies Co.

Footnotes:

[1] Base is 3500 lb. passenger vehicle operating on gasoline and certified to 1993 [illegible] emissions standard.

[2] Based on M85 due to lower energy content compared to gasoline.

[3] Vehicles will be only marketed in these years if fueling infrastructure development allows.

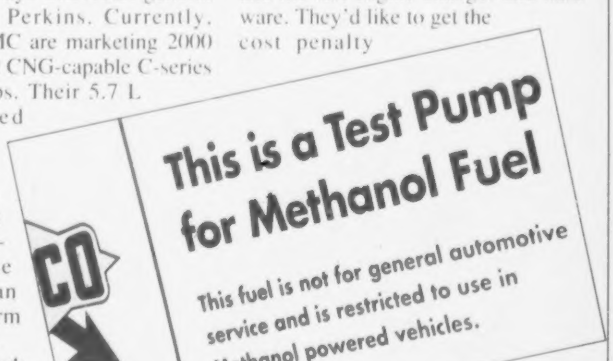
cause only these vehicles can handle lugging around two or three heavy (300-400 lb. each) fuel cylinders. And the compressed gas, which has a density similar to diesel fuel, adds 25% more weight. In a car, this means taking a big chunk of the trunk out just to fit the cylinders.

Powertrain engineers say supplier development of lightweight, possibly composite cylinders that will pass DOT fuel tank standards is needed to push CNG into smaller passenger car platforms. Mass production is also needed to lower cost, because gas cylinder manufacturing now is a very low volume, high cost venture.

"If the industry wants to sell a couple million CNG vehicles a year, instead of a couple hundred thousand, it can't do it with today's fuel cylinders," says Levy.

Ford will have 30-50 CNG Crown Victorias in test this year, says Klein, primarily in gas utility fleet duty. Later in '92 will come 50-100 E- and F-series trucks. GM is developing dedicated CNG/LPG truck engines for the mid-'90s, says Chevrolet general manager Jim Perkins. Currently, Chevy and GMC are marketing 2000 fully warranted CNG-capable C-series 3/4-ton pickups. Their 5.7 L V8s are fitted with hardened valves, valve seats and piston rings. Conversions are done by Pas Inc., an aftermarket firm in Pontiac, MI.

Chrysler, working jointly with the Gas Research Institute, has built 25 CNG-powered full-size vans, 20 of which are in fleet use across the US. Production will soon begin on up to 2000 CNG vans for 1992. Chrysler engineers say they're having a difficult time adapting CNG to their minivans and compact trucks, due to space and weight constraints.


This is a Test Pump for Methanol Fuel
This fuel is not for general automotive service and is restricted to use in Methanol powered vehicles.
CO

How are some of these vehicles faring in the real world? Pretty well, so far. According to a status report given to the Santa Barbara County air pollution control district by the engineering firm Innovative Technologies Group, the eight Ford Tauruses and one Chevy S-10 pickup in use have met TLEV standards of .125 g/mi HC, 3.4 g/mi CO and 0.4 g/mi NOx. The report notes that there have been some occurrences of above-target NOx emissions, which it attributes to quality variations in the gas and low CNG storage cylinder pressure.

Why will CNG become big? The oil companies and utilities like it. They have lots of it. Amoco and Chevron are rapidly developing pressure stations around the country. Southern California Gas has just announced they hope to have 1300 CNG stations by the year 2000 on the west coast. There are currently over 300 commercial and private natural gas refueling stations in the US.

Most CNG development going on is in dedicated vehicles. Automakers are now trying to solve CNG's added costs—about $2600 per vehicle, of which $1500 is fuel tank assemblies and the rest engine changes and hardware. They'd like to get the cost penalty down to around $500, at which point CNG becomes very viable. Some observers believe CNG motor fuel prices will become regulated. Anticipating higher CNG prices at motor refueling stations, which would increase the price of the gas for home heating and electric power, the government is already talking about putting ceilings on what the oil companies can charge on the 'rack' price of CNG. And while the CNG refueling infrastructure grows, another question arises. Should CNG

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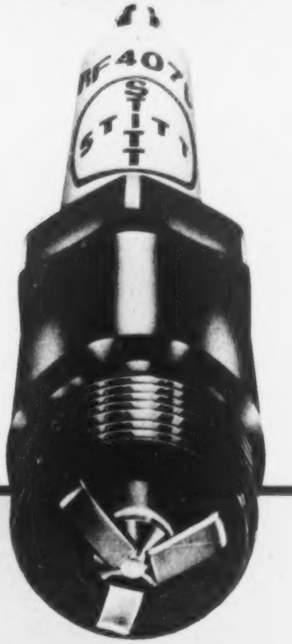

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be used in an electric plant to create electricity for electric vehicles, or should it be developed for fueling CNG vehicles?

CNG's biggest problem may be its inconsistent quality. Natural gas grades vary greatly, depending on where it comes from. And it is injected with certain other elements such as propane, to raise its quality and aid cold weather ignition. More propane can hurt emissions.

It is difficult for engineers to calibrate vehicles when the fuel's inconsistent. To a certain extent, they say engine controllers can compensate for this. Other hardware can help: Just like the meter on FFVs which monitors alcohol content, CNG-powered vehicles may have a meter which gauges gas quality.

But should CNG retailers have to screen or cleanse the gas to make it consistent in quality—which will add cost—or should they be allowed to sell any gas right off the pipeline for motor use?

The Natural Gas Coalition has contracted Southwest Research Institute to study how the differences in natural gas effects engine emissions. CNG in general reduces HC by about 66%. But right now, there is no baseline for fuel composition, says CVT's Levy. "If you've got CNG with 95% methane, 5% propane and a little bit

Driving On M85

I had to call Chrysler and check whether the flex-fuel Dodge Spirit I had was running on M85—its operation was that transparent. Except for a slight increase in cold cranking time and a decrease in distance between fuel stops, this Spirit was like any other.

With just two refueling stations presently in the Metro Detroit area, running on straight M85 could pose a problem. But then this is a flex-fuel car, and it will drink unleaded gasoline just as easily—if a bit more slowly. Unfortunately, M85 has half the energy content of gasoline, and costs the same as premium unleaded.

M85 has two advantages. First, a gas station emissions test showed HC emissions of 19 ppm (versus a standard of 220), with CO at 0.02% (versus the 1.20% standard). Second, the Spirit seemed slightly quicker on the methanol fuel.

The average consumer, however, will probably notice little difference—except for the car's changing range as the gasoline percentage rises and falls with methanol availability.

—Christopher A. Sawyer

***Methanol-fueled Dodge Spirit tested by* Automotive Industries.**

of moisture and contaminants, what will the engine's emissions be versus 75% methane, etc?" he asks.

Liquified Petroleum Gas: LPG (propane), like CNG, is restricted in current use by the size and weight of its storage system.

Therefore, its testing and use in on-road vehicles has been limited to trucks. Ford's LPG program has focused on F600 and F700 series medium-duty units. According to Harvey Klein, the company is releasing LPG for volume production on its 7.0 L truck V8 in 1993.

The infrastructure is even more extensive than with CNG, due to LPG's industrial uses. There are now 350,000 propane-fueled vehicles in the US, 300,000 in commercial and fleet use.

Durability Issues: The topic of exhaust emissions is really three topics: the emissions when the vehicle's new, how much that changes over time as the engine and emissions hardware wear, and how much variability there is from test to test and from vehicle to vehicle.

If a standard is say, 0.125 g/mi, as it is with NMHC in TLEV, automakers want to be able to certify at 4000 miles at 0.9 g/mi and still make the standard at 50,000 and 100,000 miles. They don't want to have a big gap between 4000 and 50,000 miles, because then they have to get unbelievably low numbers at 4000.

They want to reduce that 'slope,' and a lot of what they're doing in alt-fuels vehicle development is exactly that.

Questions about alt fuels remain, one of which is how automakers will pass alt-fuel costs off to the consumer. Currently, the difference in cost between a conventional gasoline-fueled California-spec car and a Federal-spec vehicle is about $200. But automakers only charge between $85 and $125 for the package.

Obviously, they amortize that cost over more vehicle lines. Can, or will those costs be spread the same way with alt-fuel vehicles?

The MVMA's Tom Hanna warns correctly that government mandates shouldn't outpace consumer acceptance, the refueling infrastructure, vehicle technology and manufacturing capabilities.

"A large number of seemingly viable fuels are seen as potential substitutes for gasoline, although each has a number of disadvantages," he notes. "It may be impossible to develop nationwide refueling infrastructures for all of them, so it's important to let free market forces—consumers and fleet owners—decide which fuels will emerge as winners." Will those in charge of making US emissions laws see it the same way? AI

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by CHRISTOPHER A. SAWYER

CAD/CAM CONUNDRUM

In March of 1991, the Industrial Technology Institute (ITI) released a report entitled 'CAD/CAM Data Problems and Costs in the Tool and Die Industry.' If not the impetus behind the creation of the Big Three's latest consortium, the CAD/CAM R&D Partnership, it highlights a major challenge facing US automakers.

According to the study, tool and die shops receive CAD data that needs corrections 51% of the time; while in 25% of the cases, the shop has to completely recreate the dataset. ITI says the problems can be grouped into three categories: send/receive translation difficulties, designer errors and CAD/CAM system incompatibilities.

The study is quite clear on what needs to be done to correct these problems (and is available through the ITI, P.O. Box 1485, Ann Arbor, MI 48106), with the last point closest to the Big Three's desire to create a common CAD/CAM language. But that is not the consortium's only goal.

The CAD/CAM R&D Partnership's direction will be set by a nine-member panel (three from each of the Big Three). Says partnership spokesman Michael Epstein, "They will look into the feasibility of a common CAD/CAM language, but the real focus will be on what's needed from the next generation of CAD/CAM."

"What's needed now," said a source within the automotive CAD/CAM community, "is for the Big Three to create a consensus, bare-minimum dataset unique to automotive design that isn't a compilation of all their present 'alphabets.' "

This common alphabet would not prevent the companies from adding proprietary enhancements to create new 'words.' "Much of this work is already taking place under the auspices of the ISO (International Standards Organization)," says our source, "but Detroit isn't that involved. Instead, they appear to have created a parallel organization to do what they could have done through the ISO with direct participation and lobbying."

The ISO's effort is called STEP (STandards for the Exchange of Product model data), and has an American arm, PDES (Product Data Exchange using STEP), that is being coordinated by the National Institute on Standards and Technology (NIST). In total, approximately 20 countries are involved in the STEP process.

"Development of the standard is well underway," says our source, "with the goal being the exchange of all product data. It's a massive standard—the largest, most complex ever written—and has taken seven years to reach this point." The first version is expected by early 1993.

When completed, the standard will establish application protocols specific to each industry involved in the process. And these can be further divided into subsets (e.g. interior, exterior, engine, suspension, etc.), and customized by the user.

GM's EDS subsidiary is involved with the STEP process, but Ford and Chrysler are said to be sitting on the sidelines.

"This isn't in their best interest," says our source. "The more people working on the process, the more focused it is, and the faster it goes. They seem to be waiting for it to materialize before they get involved." Many automotive suppliers are involved in the STEP process.

Questioning the Big Three on their plans, focus and reasoning will have to wait until the Justice Department gives the CAD/CAM R&D Partnership its blessing. This could happen as you read this. Until this cloak of silence is lifted, detailed discussion of the partnership's plans is nothing more than speculation.

Nevertheless, it's readily apparent that data errors are a leading cause of CAD/CAM problems, and a major component of tooling lead time. What is less obvious is why the Big Three have decided to go it alone, rather than work within an existing framework. AI

COST OF CORRECTING CAD DATA PROBLEMS

Time, $	Mean Cost
Excess Labor (Man Hours)	172
Project Labor Time Waste (%)	21
Excess Tooling Time (Days)	43
Project Tooling Time Wasted (%)	27
Excess Labor Time ($)*	$8648
Materials Wasted ($)	$7148
Total Excess Cost	$19,278

*At $50/hr.
Source: ITI

1992 INDUSTRY REPORT CARD

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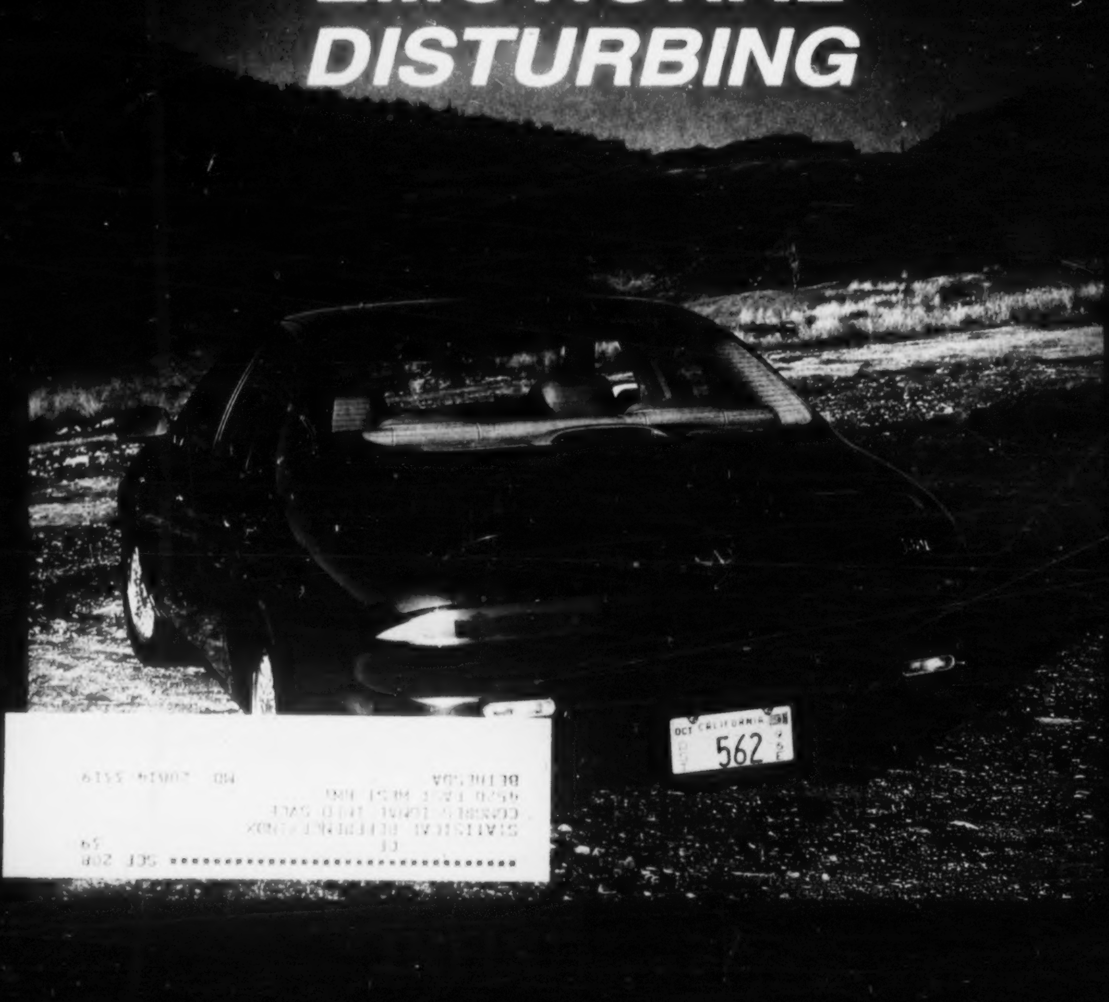

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Infiniti's new J30 is designed to stir the emotions. Here's where subliminal sells.
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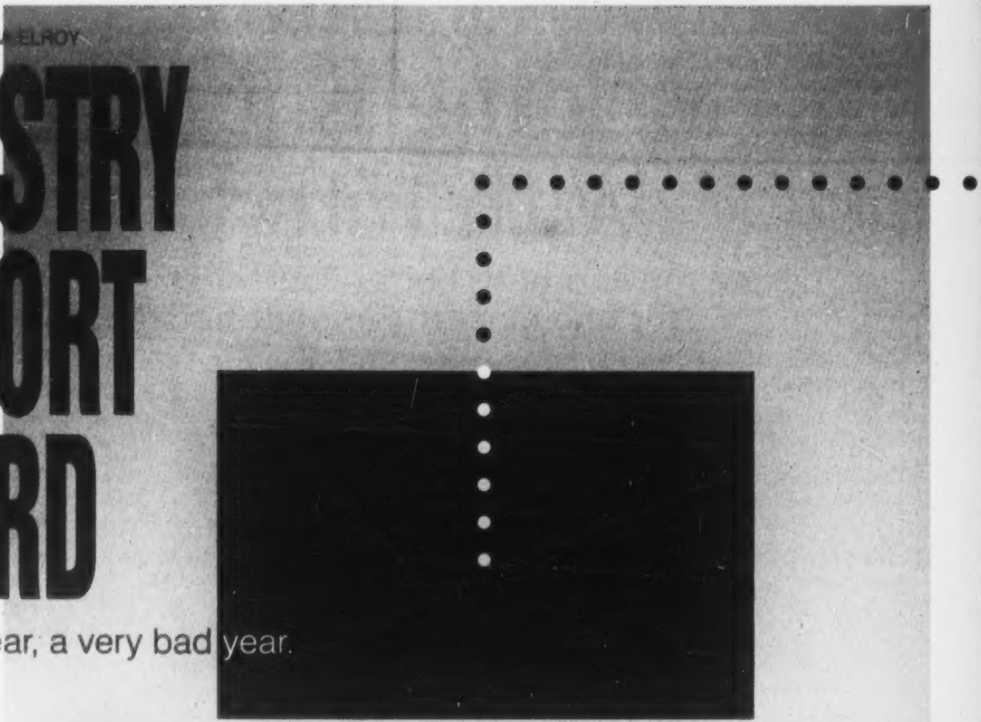

1991 was a bad year, a very bad year.

Who needs to be reminded? 1991 was a terrible year for almost every company selling cars and trucks in the US market. Sales fell 1.5 million units (11.1%) to 12.3 million units—the worst since 1983.

Yet as bad as it was, the current downturn didn't even come close to the deplorable sales years of 1981 and 1982, when 1.8 million and 1.6 million fewer vehicles were sold, respectively.

Despite the impression that it was only the Big Three which fared poorly in 1991, import brands suffered, too. For the Europeans it was a total disaster. Their sales slipped more than 26% to an annual total of only 334,000 units. For some it was far worse. Audi fell over 42%, Jaguar sales fell 50%, Porsche by more than 50%. For others it was too much. Peugeot and Rover simply gave up and dropped out of the US market.

Even the Japanese found it was a tough market. Only two months ago Daihatsu also announced it was dropping out of the US market. For the full year, sales of Japanese-brand cars fell by 100,000 (3.8%) to 2,486,000. Amazingly, more than half of this downturn came from a slump in Honda's sales. Japanese-brand trucks fell 38,000 units (51%) to 700,000. Nonetheless, sales of Japanese-brand vehicles fell less than the overall market and as a result most Japanese automakers increased their market share. Korean-made vehicles slipped 35,760 units (15.6%) to 193,000.

Amongst the Big Three, Chrysler did the best, by far. Though sales slipped 190,000 units, Chrysler ended up the year exactly where it started, with 12.2% of the US market. The company did an amazing job of increasing sales of minivans and that saved the company's market share.

Sales of GM's products in the US market fell 613,000 units to 4,320,143, and as a result the company lost only half a point of share.

Comparatively speaking, Ford did the worst and saw its sales plunge by 506,000 units, which meant it lost a full point of share.

Obviously, there is a lot more to measuring a company's success than tracking its sales and market share. That's why *Automotive Industries* once again presents its Industry Report Card in which we grade each automaker according to how it has performed in six different categories. We then compare each company against its past efforts, and sum it up its progress (or lack thereof) with an overall grade.

CHRYSLER

Quality: Chrysler showed a solid improvement in quality since last year's rating which is based on J.D. Power's Initial Quality Survey (IQS). Chrysler's defects per 100 cars decreased by 2.6%. That's the good news. The bad news is that its quality is still substantially worse than Ford's or GM's. Nonetheless, Chrysler is poised to completely replace its product line in the next five years, so we should see measurable improvements in the years to come. And since two of those product lines—the Jeep Grand Cherokee and LH cars—debut this year, we shouldn't have long to wait.

Profit/Unit: Chrysler lost about $427 on every vehicle it made last year. And though that isn't a recipe for success, at least it outperformed GM and Ford in this category. The reason for this, of course, is Chrysler's impressive cost-cutting campaign. If the company can deliver on its promise to cut back on "program" cars that are sold to fleets and rental companies, it could improve its profitability immediately. Program cars cost Chrysler an estimated $3000 in incentives per vehicle, which is twice the average cost of rebates it uses in the retail market.

Market Share: Despite all the bad press about sinking sales that Chrysler suffered in 1991, many in the media seemed to have missed one crucial point. Chrysler didn't lose any market share during the year—absolutely none. Market share of cars was down only 0.63 points, but on the truck side Chrysler made up for that. Minivans sales surged strongly due to a new design, a special $14,000 package on short wheelbase versions, and very aggressive marketing including rebates. The Dakota also showed surprising strength. Could it be that Chrysler has finally found a new niche in the truck market?

Return on Sales: Chrysler's bottom line looked terrible last year. But at least there are some glimmers of hope for 1992. For one thing, the company came very close to turning a profit in the fourth quarter, not including its sale of Diamond-Star. Had sales been stronger, it would have turned an operating profit even without the income from the Diamond-Star sale. Today, of course, sales are starting to pick up. Better still, with the Grand Cherokee and LH cars, Chrysler will be in higher-profit segments, and that bodes well for the bottom line.

Productivity: In 1991 Chrysler added 3000 employees to the payroll at the same time vehicle output was plunging. That hurt its productivity numbers, which fell 8.3% compared to the year before. Unfortunately, our productivity measure—vehicles/employee/year—doesn't account for a drop-off in sales caused by a downturn in the marketplace. And that's the only thing that seems to have caused the company's slide in this category.

Inventory Turns: Chrysler's manufacturing people performed something of a miracle in the last year. Even though vehicle output in Chrysler's factories fell 7%, inventory was reduced by a whopping 21%. Translated into dollars, that means the manufacturing people freed up at least $150 million for a corporation that is hard-pressed for cash. If this is indicative of what the manufacturing staff can achieve in a terrible market, then it is truly becoming a valuable asset for the corporation.

Chrysler

Category	1973	1978	1987	1988	1989	1990	1991	'91 Grade
Quality (Defects/100)	----	----	178	202	169	172.5	168	A
Profit/Unit	$127	($129)	$853	$649	$249	$209	($427)	F
Market Share	15.6%	11.2%	12.3%	13.9%	13.7%	12.2%	12.2%	A
Return on Sales	2.1%	(1.5%)	4.5%	3.0%	1.0%	0.2%	(2.7%)	F
Productivity*	13.0	13.1	16.2	18.0	19.5	17.9	16.4	D
Inventory Turns	5.6	6.3	16.8	21.6	26.3	22.5	26.0	A+

1991 Overall Grade: C

* Cars/Employee/Year

FORD

Quality: Ford's quality improvement was nothing short of phenomenal in 1991. In the last year the company achieved an impressive 10.5% gain and pulled itself into the top five companies on the Initial Quality Survey prepared by J.D. Power. The only companies that now exceed the Ford Motor Company's overall quality rating are Toyota, Mercedes, Honda and Subaru—in that order. However, Honda and Subaru are barely ahead of the Ford Division. The typical Ford only has 0.01 more defects than a typical Subaru, and only 0.16 more than a Honda. And a typical Lincoln only has 0.22 more defects than an Acura.

Profit/Unit: Ford lost over $700 on every vehicle it sold last year. Not only does that reflect the tough times the company has faced in the North American market, it shows that the profitability of the company's once-strong European operations has collapsed. Actually, we should say the collapse of Ford's UK operations. While Ford made a profit on the continent, combined losses at Jaguar and Ford of Britain came to $1.1 billion. And the future doesn't look too bright. Though sales in the US are expected to start to turn around this year, the European market is expected to be very weak, especially since last year's sales boost from German reunification will not be there to mask the slowdown elsewhere in the EC.

Market Share: Ford's quality rating may have improved dramatically, but from a sales standpoint 1991 was abysmal for the company. In an industry that fights tooth and nail over tenths of a share, Ford lost a full point of market share. None of Ford's cars sold better than the year before, save the Tracer and Capri. However, the Taurus/Sable and Tempo did manage to increase share in their segments.

On the truck side Ford did somewhat better and only lost $^3/_{10}$ths of point of market share. The real bright spot, of course, was the Explorer, which literally blew all its competitors by the wayside. And by the end of the year the Aerostar and the restyled F-series were showing real strength.

Return on Sales: Anyway you measure it, Ford's financial performance was dismal in 1991. In total, the company lost $2.3 billion. And the losses on automotive operations were even worse: $3.2 billion in red ink. However, by the fourth quarter the company was losing less money on lower volume compared to 1990—hardly something to brag about—but at least it shows that Ford could be ready to quickly work its way back to profitability with an upturn in the US market.

Productivity: Just as it did in quality, Ford achieved an amazing improvement in productivity. A miniscule part of this improvement is due to the fact that Ford's New Holland tractor operations were sold, and those employees and their output are not factored into the 1991 productivity figures. Ford's improvement shows that the company is getting better worldwide—not just in the US. Even so, Ford is still not up to the efficiency rating it achieved several years ago.

Inventory Turns: When it comes to managing its manufacturing operations, Ford is truly achieving constant improvement. Even though worldwide sales declined in 1991, and many US plants had to be temporarily closed from time to time, Ford was able to turn over its inventory more often. This helps to explain why the company's quality keeps getting better and better—with less inventory lying around, any quality problem quickly rises to the surface, where it can be identified and eliminated.

Ford

Category	1973	1978	1987	1988	1989	1990	1991	Grade
Quality (Defects/100)	----	----	156	169	143	147.6	132	A+
Profit/Unit	$260	$360	$1023	$1014	$663	$53	($700)	F
Market Share	29.8%	26.5%	23.1%	23.7%	24.6%	23.8%	22.8%	D
Return on Sales	3.9%	3.7%	6.4%	5.7%	3.9%	0.8%	(2.5%)	F
Productivity*	13.7	13.8	18.7	19.9	19.6	16.5	17.9	B
Inventory Turns	5.3	6.5	15.6	17.3	18.0	21.0	21.8	A

1991 Overall Grade: C

* Cars/Employee/Year

GENERAL MOTORS

Quality: Our quality rating, which is based on J.D. Power's Initial Quality Survey (IQS), shows that GM's quality trend went in the wrong direction. The number of defects per 100 vehicles increased by 1% from last year's rating. In today's quality-conscious market, that's a bad omen. Once again B-O-C took top quality honors at GM, placing in the top 13 of all 34 brands that are ranked in the IQS.

Surprisingly, Buick fell substantially in the ratings, but Olds and Cadillac more than made up the slack. Saturn placed in the middle of the pack—not bad considering it was the first time it was ranked. The biggest drag on GM's overall quality rating came from Pontiac, Geo and Chevrolet which saw their quality drop significantly.

General Motors

Category	1973	1979	1987	1988	1989	1990	1991	Grade
Quality (Defects/100)	----	----	176	165	158	149	150.5	D
Profit/Unit	$490	$684	$435	$692	$645	($462)	($883)	F
Market Share	51.5%	47.3%	34.7%	34.9%	35.0%	35.5%	35.1%	A
Return on Sales	6.7%	5.5%	3.5%	4.4%	3.8%	(1.6%)	(3.6%)	F
Productivity*	11.4	12.1	11.3	12.9	12.6	12.0	11.8	C
Inventory Turns	5.4	6.7	18.0	18.8	20.0	19.3	16.5	D

1991 Overall Grade: D

* Cars/Employee/Year

Obviously, something isn't working right at C-P-C, at least as far as the IQS is concerned.

Profit/Unit: General Motors lost an average of $883 on every vehicle it sold in 1991.

But that's a worldwide average. In the United States the losses were far worse. GM lost close to $2000 on every vehicle it sold in the US last year, compared to a profit of nearly $1000 on every vehicle it sold in Europe. GM also turned a profit in Canada and Latin America. Obviously, GM must turn its US operations around.

And as with its problems in quality, GM's big problem with losses on its automotive operations lies with C-P-C.

Market Share: GM struggled to hold onto market share all year and did a valiant job with its passenger cars.

Despite a falloff of 400,000 passenger cars, its share was up 0.15 points—not much, but at least it was in the right direction. Yet, virtually all of the credit for this goes to Buick,

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which enjoyed strong sales all year long. However Saturn can't be ignored either. By putting in a full 12 months' worth of sales, it helped GM increase its share.

But on the truck side GM fared poorly. It lost 154 points of share, which translated into a drop of 218,000 units. Sales were especially weak in full-size pick-ups and vans.

Return On Sales: From a financial standpoint 1991 had better go down as the poorest performance in GM's history. It's hard to imagine it could ever get worse.

Losses at the company's automotive operations grew 80% compared to 1990. And the growing red ink came despite a massive headcount reduction program, severe pressure on suppliers to cut costs, and a 50% cut in the dividend.

The recently announced restructuring will undoubtedly help GM cut costs in the future. But it could still take years before this takes effect—even after the market comes back.

Productivity: With sales dropping precipitously in the US market, it's not surprising that GM's productivity fell. Virtually no company can increase its overall efficiency under these circumstances. Factories have to be kept open and run at slow line rates to keep some amount of product flowing to the market. The fact that GM's productivity didn't fall more probably reflects substantial productivity gains at the company's operations in Europe.

Inventory Turns: The same reasons that explain GM's declining productivity should explain its decline in inventory turns.

On the other hand, both Ford and Chrysler were able to increase their turns despite the same adverse business and sales conditions. This suggests that GM was simply not able to do as good a job as its domestic competitors. AI

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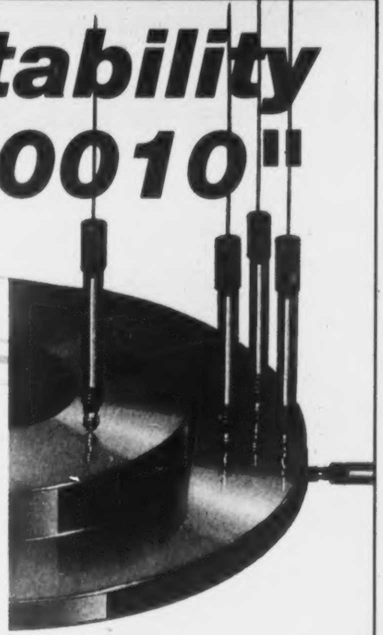

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by JOHN McELROY

R&D SPENDING COMPARISON

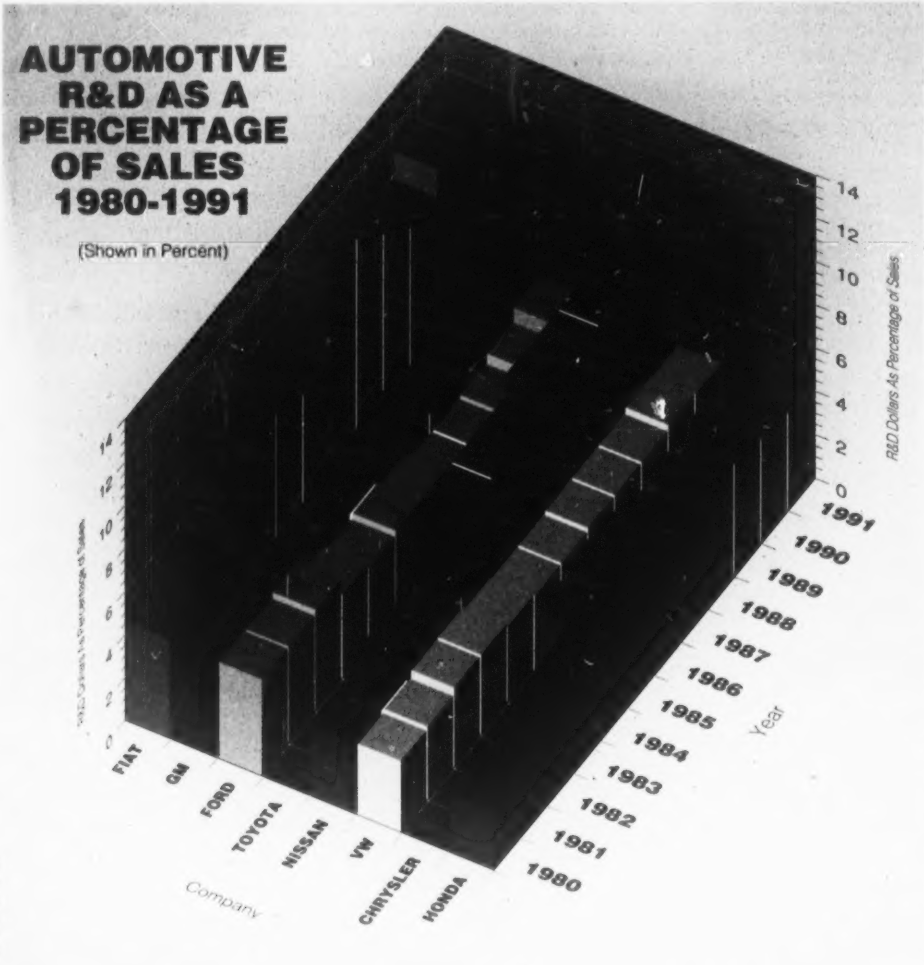
Why do Japanese automakers have a sparkling reputation for innovation? They put proportionately more resources into Research and Development than the Europeans or Americans.

Based on an *Automotive Industries* comparison of R&D spending over a 10-year period, it becomes readily apparent why Japanese automakers have earned a sparkling reputation for technological innovation: Japanese automakers commit proportionately more resources to research and development than their US or European counterparts.

Moreover, just as Japanese car companies are able to design new products or build new factories for much less investment than their Western counterparts, it is likely they also get a lot more 'bang for their buck' in their R&D expenditures. For example, even though Toyota spends about the same on R&D as Ford, and Nissan spends about the same as VW, both Japanese companies are introducing more new products and features into the marketplace, and they're doing it more often.

Because Japanese automakers spend more money as a percent of total sales on R&D, they have caught up to the bigger Western automakers. Though Toyota is smaller than Ford, it spends nearly as much on R&D.

And Honda, which is a smaller company than Chrysler, caught up to the US automaker in R&D in 1986 and has outspent it ever since. Additionally, GM and Ford must spread their R&D investment over a larger production base. And since Japanese automakers are less vertically integrated than GM and Ford, they can leverage the R&D spending of their suppliers for an even greater technology advan-



AUTOMOTIVE R&D AS A PERCENTAGE OF SALES 1980-1991

(Shown in Percent)

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tage. What the figures in these charts don't reveal is how much of this R&D money is spent on the 'R' or how much is spent on the 'D.'

But if industry norms are any indication, it's likely the Japanese have an advantage here as well. American and European automakers seem to spend more time de-bugging new products and technologies, which means less of their R&D money is being spent purely on research.

Another difficulty in comparing R&D expenditures is figuring out how companies compile their figures. When one looks at Fiat, for example, the figures strongly suggest that the Italian automaker is including many other costs in its R&D expenditures that other companies don't use. Fiat likely incorporates product-related expenses, such as new-product launch costs that its competitors don't consider to be part of research or development.

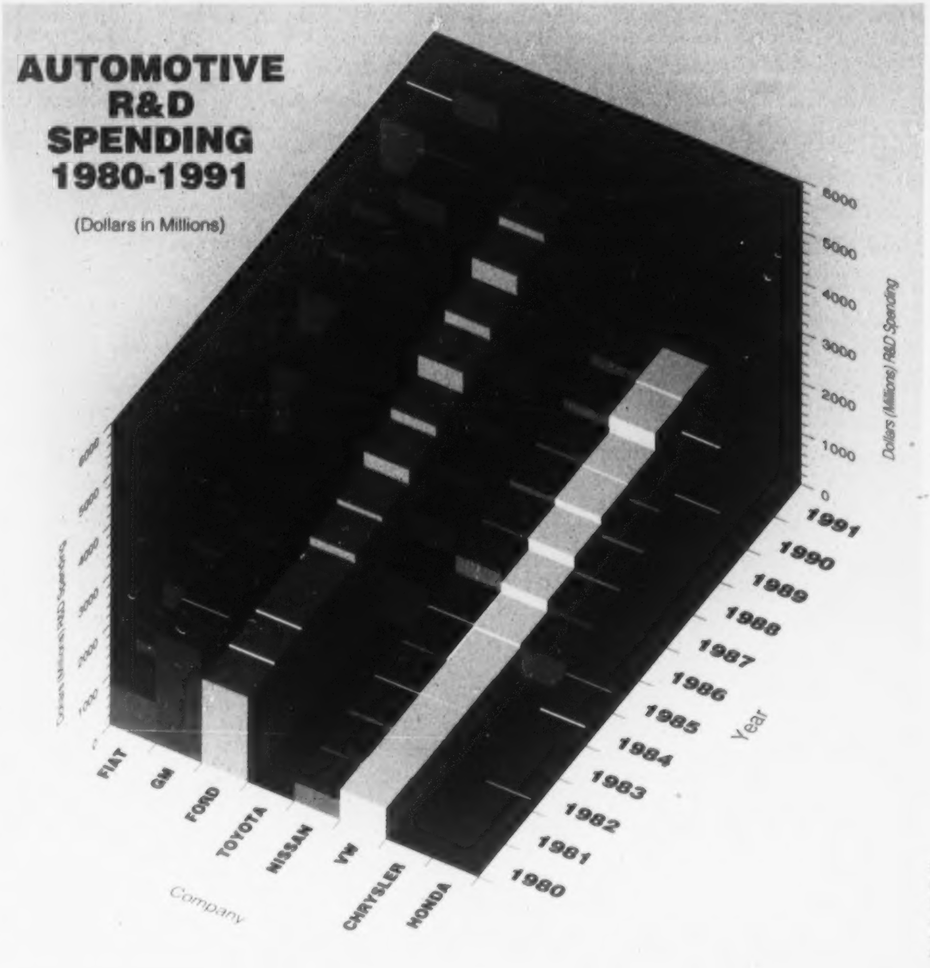
Of course, measuring R&D expenditures isn't necessarily the best way of determining which automaker is gaining a technological edge on its rivals. There are numerous examples of Japanese automakers developing technologies that are little more than gimmicks. The talking dashboard fiasco that Nissan initiated in the early 1980s is the most classic example (though the limited value to the customer certainly didn't prevent Chrysler or General Motors from following suit). More recently, several Japanese automakers have beat their Western competitors to the market with four-wheel-steering, and digital signal processing technology for radios. Though not gimmicks, they have been a sales flop everywhere but in the Japanese home market. And even though these two technologies could still emerge as important innovations, consumers in the US and Europe certainly haven't seen much value in them as they're currently being implemented.

Another important caveat in determining which automaker has a technological edge is the temporary nature of that edge. In today's auto industry, a technological lead is often measured in months. At most, an automaker will enjoy a lead of 12 to 24 months. And that may only serve to test the waters, allowing other automakers to avoid the leader's marketing mistakes.

Since any component or feature can be acquired by a competitor, taken apart and reverse-engineered, the followers can often be right on the heels of the leader for only a fraction of the R&D investment. Throughout the 1950s, 1960s and 1970s this was a favorite tactic of Japanese automakers.

This points out the need to emphasize process development over product development. In today's global economy, where product technology can be quickly transferred anywhere in the world, the advantage is going to go to that company which can manufacture it at a lower cost with higher quality.

Though the R&D spending figures


AUTOMOTIVE R&D SPENDING 1980-1991

(Dollars in Millions)

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in these charts don't break down how much goes to process development or how much goes to product development, it would seem safe to say that once again the Japanese are out in front. And process technology, which is not available in a dealer's showroom and can be kept away from competitors' prying eyes, is an area where a company can enjoy an advantage for a long time. Toyota's Flexible Press System (hydro-forming), and Nissan's IBAS (intelligent body assembly system) are but two recent examples of process technology that are years from being implemented by Western automakers.

Finally, it should be noted that since the R&D expenditures in these charts are expressed in US dollars, exchange rates have exaggerated the increases at Toyota, Nissan, Honda, Volkswagen and Fiat since the mid-1980s. The value of the yen increased 30% in 1986, the lira increaseed 22%, and the Deutschemark increased 17% in 1987. Nonetheless, since the Japanese automakers spend a greater percentage of sales on R&D they are still committing proportionately more resources, and are likely to increase their advantage in technology in the years to come. *AI*

Worldwide Automotive Research & Development

Company	Year	Factory Sales	$ R&D Spending	$ R&D as % of Sales
FIAT	1980	2,397	830	4.6
	1981	1,967	1,060	6.0
	1982	2,045	1,580	6.8
	1983	2,185	1,740	9.1
	1984	2,267	1,870	9.0
	1985	2,058	1,960	8.3
	1986	2,317	3,330	13.0
	1987	2,648	4,170	12.5
	1988	2,731	4,330	11.2
	1989	2,983	4,560	10.0
	1990	2,858	5,610	11.2
	1991	2,694	5,650	11.2
GM	1980	7,101	2,224	3.8
	1981	6,762	2,250	3.5
	1982	6,244	2,175	3.6
	1983	7,769	2,602	3.5
	1984	8,256	3,076	3.6
	1985	9,305	3,625	3.7
	1986	8,576	4,158	4.0
	1987	7,765	4,361	4.2
	1988	8,108	4,754	3.8
	1989	7,946	5,247	4.1
	1990	7,451	5,341	4.2
	1991	7,015	5,887	4.8
FORD	1980	4,426	1,675	4.5
	1981	4,402	1,718	4.5
	1982	4,328	1,764	4.7
	1983	5,001	1,751	3.9
	1984	5,667	1,915	3.6
	1985	5,634	2,018	3.8
	1986	5,984	2,305	3.6
	1987	6,115	2,514	3.1
	1988	6,517	2,930	3.1
	1989	6,408	3,167	3.2
	1990	5,872	3,558	3.6
	1991	5,359	3,728	4.2
TOYOTA	1985	3,535	974	4.0
	1986	3,685	1,528	4.0
	1987	3,689	1,816	4.0
	1988	3,872	2,170	4.0
	1989	4,113	2,785	5.0
	1990	4,429	3,004*	5.0*
	1991	4,538	3,570*	5.0*
NISSAN	1980	2,472	397	3.3
	1981	2,617	453	3.3
	1982	2,557	542	4.2
	1983	2,462	568	4.2
	1984	2,499	625	4.0
	1985	2,473	650	4.3
	1986	2,427	1,009	4.5
	1987	2,633	1,072	4.5
	1988	2,536	1,209	4.5
	1989	2,789	1,303	5.0
	1990	2,936	1,517	5.5
	1991	3,127	1,764	5.9
VW	1980	2,529	605	3.3
	1981	2,279	574	3.4
	1982	2,120	576	3.7
	1983	2,127	587	3.7
	1984	2,145	562	3.5
	1985	2,398	611	3.4
	1986	2,758	829	3.4
	1987	2,774	1,056	3.5
	1988	2,854	1,195	3.5
	1989	2,941	1,222	3.5
	1990	3,030	1,546	3.7
	1991	3,300	1,598*	3.6*
CHRYSLER	1985	2,157	609	2.8
	1986	2,198	731	3.2
	1987	2,450	798	3.0
	1988	2,566	881	2.4
	1989	2,381	954	2.7
	1990	1,984	908	2.9
	1991	1,866	955	3.2
HONDA	1980	3,447[a]	143	2.7
	1981	3,907[a]	222	2.7
	1982	4,562[a]	249	3.1
	1983	4,776[a]	348	3.7
	1984	4,306[a]	397	3.9
	1985	4,206[a]	424	4.1
	1986	4,446[a]	730	4.5
	1987	4,205[a]	947	5.0
	1988	4,533[a]	1,361*	5.3*
	1989	4,935[a]	1,391	5.2
	1990	4,923[a]	1,176	4.8
	1991	5,313[a]	1,376	4.5

Source: Annual Reports, Company Literature

* Estimate [a] Includes Motorcycles

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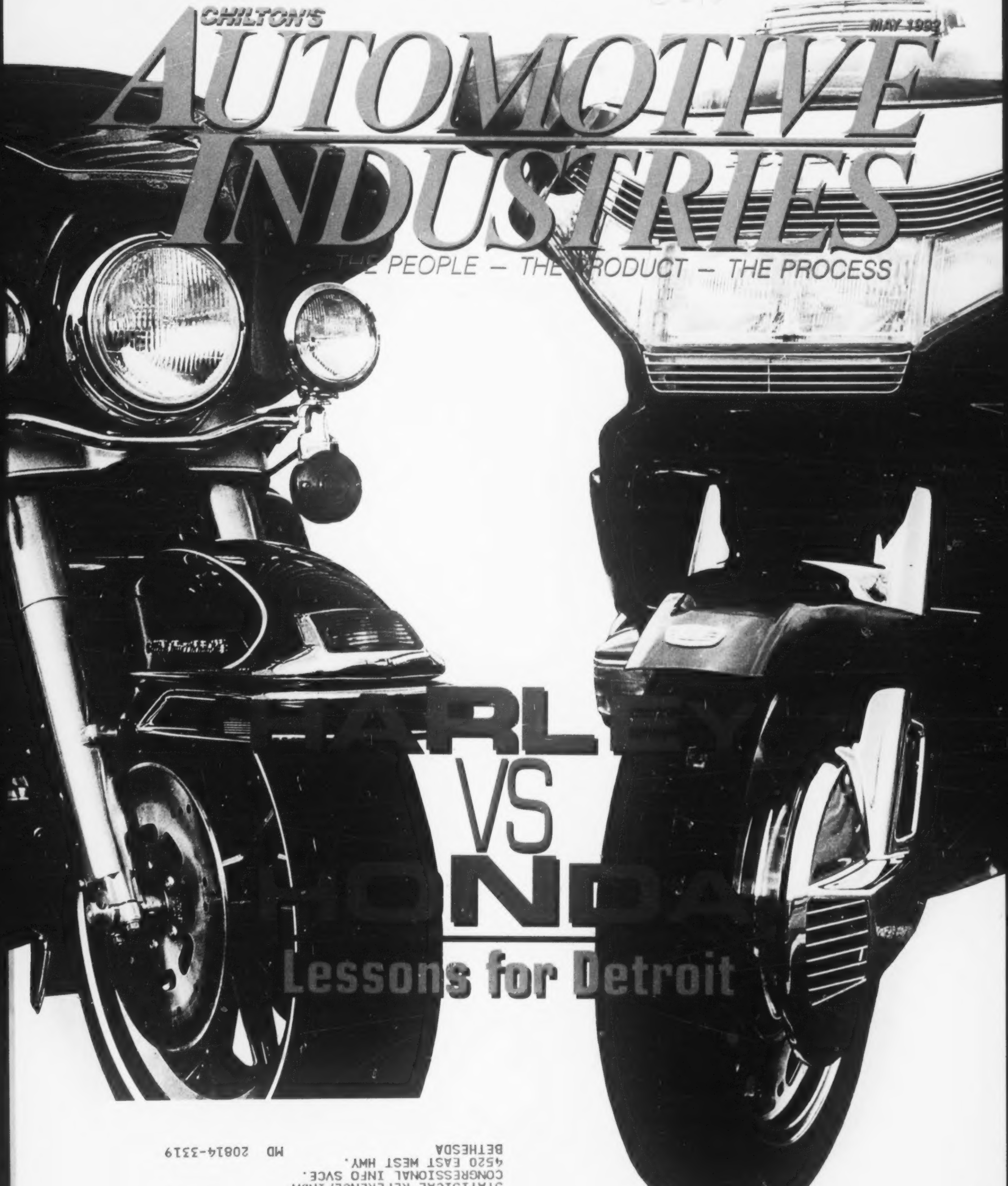
AUTOMOTIVE INDUSTRIES

THE PEOPLE – THE PRODUCT – THE PROCESS



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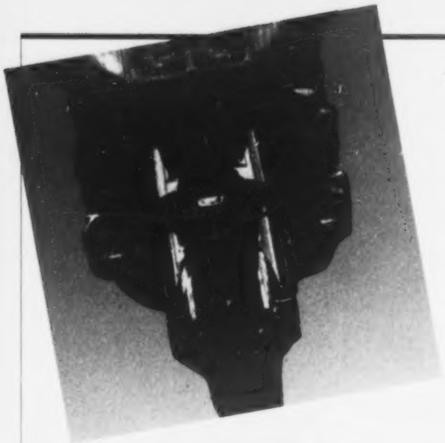

Harley-Davidson Electra-Glide Ultra Classic (left) and Honda Gold Wing SE.
COVER PHOTOGRAPHY: LINDSAY BROOKE

COVER STORY

Harley vs. Honda **24**
Innovative manufacturing at America's big bike maker.
by Lindsay Brooke

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IVHS

intelligent vehicle highway systems

Congress Approves $659 M For IVHS R&D

But down the road, IVHS will require billions.

by JIM HAUGEN

For the last five years, IVHS proponents have been looking forward to the day when IVHS R&D activities would be funded at a reasonable level by Congress. That day has finally arrived. The legislation is actually designated as ISTEA—standing for Inter Modal Surface Transportation Efficiency Act. But amongst IVHS people it's popularly known as "iced tea."

The purpose of this act is: "To develop a National Inter Modal Transportation System that is economically efficient, environmentally sound, provides the foundation for the nation to compete in the global economy and will move people and goods in an energy-efficient manner."

The scope of ISTEA includes construction and maintenance of our National highway system; highway and motor carrier safety; mass transit capital and operating funds. Interestingly it also contains funding for a magnetically levitated vehicle program. The act provides total funding of about $155 million over the six fiscal years from 1992 to 1997.

Most importantly, the Act authorizes a total of $659 million for IVHS R&D during the six-year funding period. This is a giant step upward from the $3 million of IVHS funding in 1990 and $23 million provided in 1991. Compared to R&D funding levels for military and space programs, this is still a relatively trivial amount. But it takes time to assemble sensible programs and the trained personnel to accomplish the needed R&D. Is it sufficient for now? Yes. And additional funds will be most likely appropriated as combined government/industry work demonstrates meaningful results. IVHS funding has been in the classic "chicken/egg" situation. Industry has been reluctant to commit to IVHS R&D without some assurance that government funding would be available for deployment of necessary supporting infrastructure. And the government has been reluctant to step in without assurance that an industry willingness exists to commit to the necessary R&D work to develop new IVHS products.

ISTEA

■ **Corridors Program**	**Each FY**	**Total**
FY 92	$71 M	$71 M
FY 93-97	$86 M	$430 M
		$501 M
■ **Tech. Assistance, Planning, Operational Test Activities**		
FY 92	$23 M	$23 M
FY 93-97	$27 M	$135 M
		$158 M
		$659 M

■ Maximum Federal Share = 80%

Fiscal Year Total Availability

FY 92: $139.8 M (GOE) + $94 M (ISTA) = $233.8 M

FY 93: $30.0 M (GOE) + $113 M (ISTA) = $143.0 M

FY 94-97: $?? (GOE) + $113 M (ISTA) = GOE + 113.0 M

The attached figure (provided courtesy of Lyle Saxton, Associate Director for IVHS Policy and Coordination at the Federal Highway Administration) summarizes the funding breakdown for the ISTEA program, along with additional funds appropriated funds, entitled General Operating Expenses (GOE). These are actuals for Fiscal Year 1992, and expected totals in fiscal years 1993–1997. As shown, a total of $233.8 million is available in FY '92. With local and state matching funds added, the total funds available could be close to $300 million.

The highest priority for funding will be certain designated transportation corridors which have high levels of congestion and pollution. Anywhere from three to ten corridors will be designated as priority corridors and receive 50% of the corridors funds. These priority corridors must meet specific criteria such as high traffic density; severe or extreme ozone non-attainment; no expansion of the current highway system; and have a mix of passenger, transit and commercial vehicle traffic. Some example corridors meeting such criteria are:

☐ Washington/Baltimore inter city
☐ Chicago/Milwaukee inter city
☐ Los Angeles/Anaheim inter city
☐ Chicago ADVANCE intraurban corridor
☐ Los Angeles SMART corridor
☐ Houston

Another intriguing feature of the

ISTEA Act is its planned support of the development of an automated highway system. The legislation specifies that such a system should be demonstrated in prototype form or as a test track demonstration system by 1997. This is anticipated to be a several hundred million dollar project over this period. Its successful completion will require the establishment of one or more consortiums which combine the knowledge and abilities of companies from the automotive, communication/electronics and highway industries. These companies will be expected to demonstrate their commitment to such a project by resource sharing with the government.

> **Most importantly, the Inter Modal Surface Transportation Efficiency Act authorizes a total of $659 million for IVHS R&D during the six year funding period.**

The ISTEA money might be termed "seed" money. This IVHS R&D support should lead to a multitude of new prototype products which are ready for deployment throughout our cities and on our National highways. Then the real funding support comes into play. Before IVHS is a reality for us all to use, hundreds of billions of dollars will be spent, for public infrastructure and, by the consumer, for operating products.

It's amazing to be able to contemplate an evolving attitude in this country, where we actually spend billions on improving the quality, productivity and safety of our surface transportation infrastructure instead of spending more on weapons systems. I left the aerospace industry some 25 years ago with the hope of participating in such a world. ISTEA is a very major first step. Those much maligned Congressmen are definitely doing something right with their support of IVHS. AI

ENGLEHARD TO BUILD AUTO EMISSIONS CATALYST PLANT IN GERMANY

Englehard Corp—Englehard Corp. has purchased the other half of its German joint venture, Englehard Kali-Chemie GmbH.

Englehard will now build a new $25 million manufacturing plant in Nienburg, Germany to meet the demand for automotive emission catalysts in the European Community.

Englehard, which owned half of the joint venture company, paid an undisclosed amount of cash for the remaining 50% held by Kali-Chemie AG, a wholly owned subsidiary of Solvay Deutschland GmbH.

PACKAGING INSERT ON EPS FOAM RECYCLING AVAILABLE

Assoc. of Foam Packaging Recyclers—To help users of EPS foam respond to their consumers' concerns about the environment, the Association of Foam Packaging Recyclers (AFPR, 1025 Connecticut Ave. NW, Ste. 515, Washington, DC 20036) released a packaging insert which any user of protective foam packaging can place in the box with their consumer products.

The insert provides a toll-free number which consumers can call to find the nearest EPS foam recycling location. It also emphasizes the fact that manufacturers of EPS foam reprocess the recycled foam into new packaging made from post-consumer waste.

FIBRIT SHIPS INSTRUMENT PANELS TO VW IN MEXICO

Fibrit Enterprises Inc.—American Fibrit Inc. has begun producing and shipping instrument panels for 1992 Mexican-made Volkswagen Golf and Jetta models.

The effort is the result of a program management approach led by American Fibrit, its German parent Deutsche Fibrit and Volkswagen AG (Germany), Volkswagen of America, and Volkswagen do Mexico.

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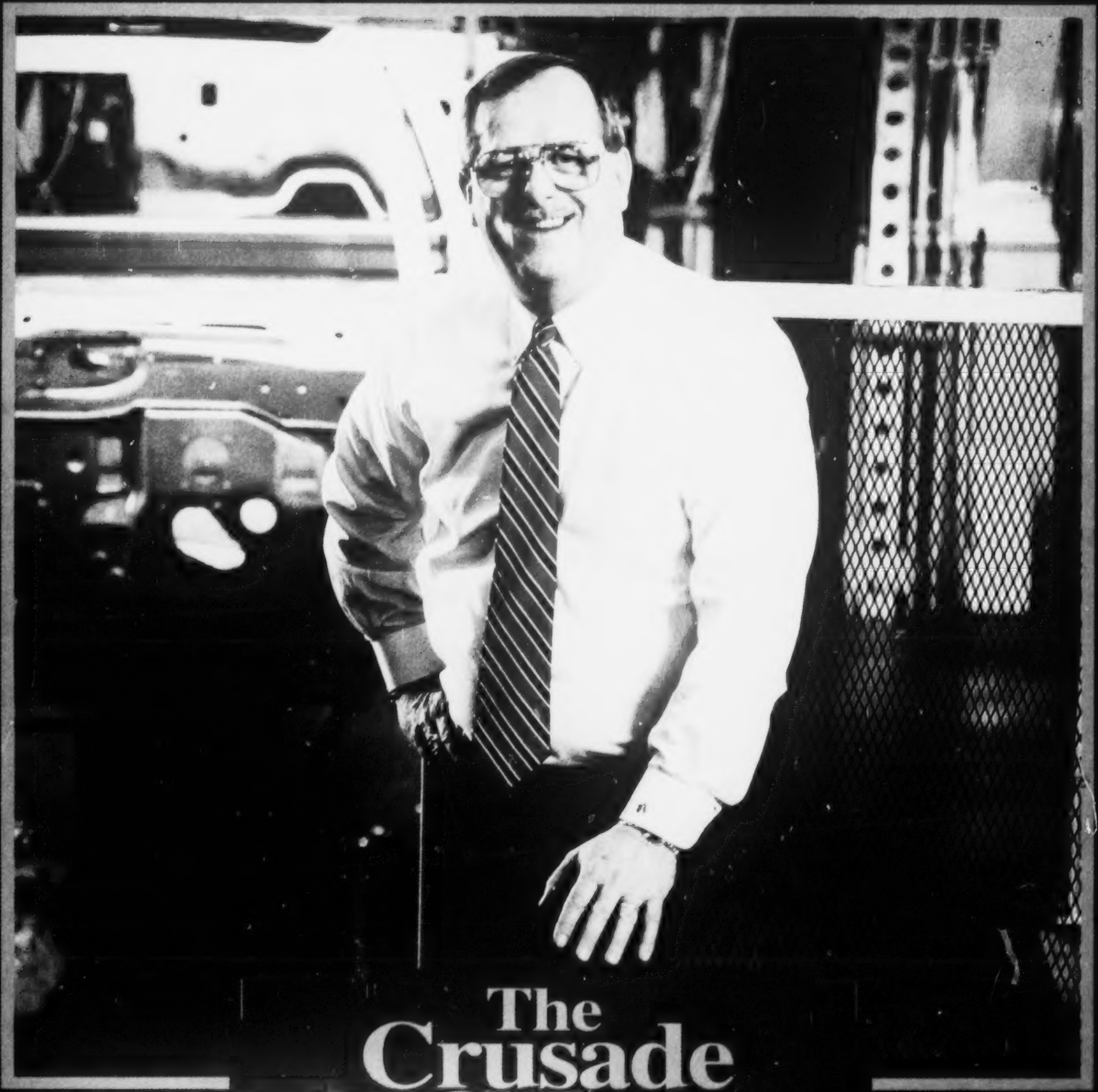
JUNE 1992

THE PEOPLE — THE PRODUCT — THE PROCESS



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Volume 172, No. 6 June 1992

CHILTON'S
AUTOMOTIVE
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Chrysler's vp of manufacturing Dennis Pawley presses a grass roots crusade.
COVER PHOTOGRAPHY: JAY ASQUINI

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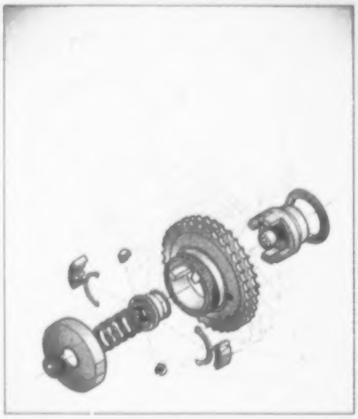
BPA ABP

ALL IN THE TIMING

AC Rochester has patented a variable valve timing system, which according to the division will enter production on a GM engine "in the mid-'90s."

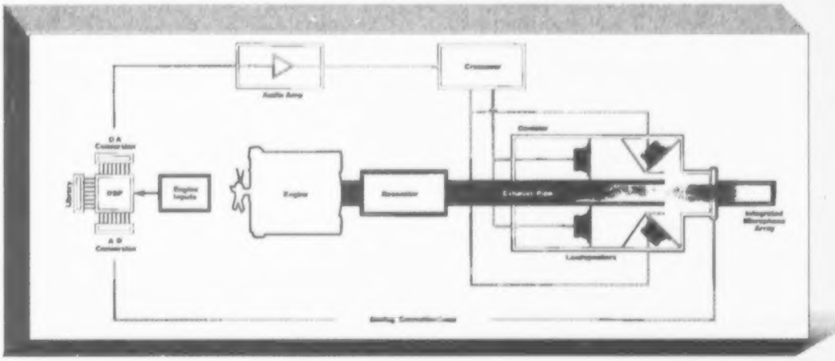
Designed to fit inside the camshaft's drive sprocket, **AC's Variable Cam Phaser (VCP)** consists of two opposed packs of helically shaped blocks. Shown here, the block packs are moved by a central plunger, controlled by oil pressure and springs.

As they move, the phase angle between the camshaft and sprocket is altered, shifting the cam between 'retard' and 'advance' timing modes.



AC ROCHESTER

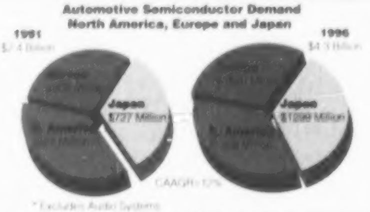
PIPE DREAMS



Arvin Industries is developing this **tunable electronic muffler system** for a mid-'90s luxury car. The analog-to-digital system tracks engine speed at up to 5 rpm/ms; Arvin predicts 3-5% fuel economy gains. Contact Joe Atkins, president of Arvin's OEM group, at 812-379-3399. Fax 812-379-3227.

LET THE CHIPS FALL

Automotive semiconductor sales grew a strong 7% to $2.47 billion worldwide in 1991 says BIS Strategic Decisions. The British market-research firm forecasts that **demand for semiconductors in the US, Europe and Japan will grow to $4.4 billion in 1996**—a compounded growth rate of 12% per year—not including audio systems. The highest growth rate, 14% per year, is expected to take place in Europe, largely due to stricter emission regulations that will take effect at the end of this year. Growth in the US is forecast at 10% a year, with highest growth by value coming from multiplexing, ABS, adaptive suspensions and airbags. Japanese growth of 12% a year will be powered by many of the same factors, plus navigation systems.



STRAIGHT SHOOTER

Lotus Engineering, with England's Defense Research Agency's Military Division, has **fitted active suspension to an Alvis Scorpion light tank**! Ride comfort is increased, letting the tank travel faster over rough terrain. Gun aim and control is also improved. Even more bizarre, Lotus is also working on special horseshoes for UK race horses. The shoes are designed to prevent hoof and leg injuries on hard dirt surfaces.

[NEWLINES Continued On Page 190]

by JOSEPH M. CALLAHAN

CHRYSLER'S CRYSTAL BALL

They predicted the start of the current recession. Now Chrysler's chief economist and his tiny staff are zeroing in on the recovery.

Chrysler chief economist Donald P. Hilty

"We're running Chrysler on the basis that there will be no recovery until August, at least," says Donald Hilty, Chrysler Corporation's chief economist. "We're ordering our materials and producing vehicles in preparation for a sales rise in the Autumn."

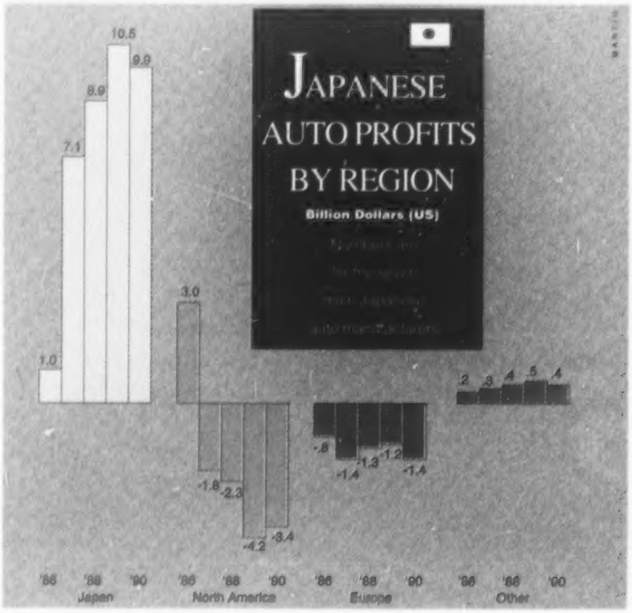
Hilty's outlook comes from the *Auto Industry Leading Indicators*, a compilation of over two dozen economic indicators made by Hilty and his six-person Economics staff. (Hilty had to persuade former vice-chairman Gerald Greenwald to resurrect Chrysler's Economics staff in 1980. He was put in charge and has headed it ever since.) Getting these indicators right means accurately predicting a recovery or a recession.

Despite his cautious optimism for 1991 an 8% rise in US vehicle sales the Leading Indicators are still not strong enough for Hilty to tell Chrysler chairman Lee Iacocca that the current recession will end soon, or that Chrysler should prepare for a return of strong sales. Each month, Hilty summarizes the eight Leading Indicators for Chrysler's Board. 'Stop light' colors are assigned to each Indicator. When enough of the indicators turn from red or yellow to green for three consecutive months, Hilty passes the word along to Iacocca, to Chrysler's production planning and purchasing staffs, and others.

"It seems to work," he says, noting that Chrysler accurately predicted when the current recession would start. "The biggest problems we have are Consumer Attitudes and Disposable Income. Both of these have changed to 'yellow' recently, from 'red'." The six other Leading Indicators are Price Pressures, Interest Rates and Unemployment Claims ('green'); and Workweek, Stock Market and Consumer Debt ('yellow'). To identify the all-important Consumer Attitudes, Hilty's staff combines the findings of the University of Michigan and the Conference Board, a non-profit business research organization.

"Consumers are more pessimistic than they were in 1982," he comments. "This is worrisome to us, and we think the Bush Administration should be looking at this, rather than thinking it's going to be a shallow recession. The average of these two indices seems to improve a few months before the auto industry improves." He lists health care costs, US tax system, and the high cost of US capital as the three major problems facing American automakers in their drive to become internationally competitive. For example, Chrysler pays $700 for health care on each car it builds. He also notes that while most other industrial countries finance their governments through consumption or Value Added Taxes, the US uniquely persists in production taxes. The VAT encourages exports because it's not applied to exports, he says, thereby making the products of these countries very competitive overseas. Hilty also sees other trends in the auto industry:

- ❏ Federal Reserve chairman Alan Greenspan has indicated he's aiming for a less than 2% annual inflation rate, compared with the current 3%.
- ❏ The industry's current over-capacity situation will probably decline toward the mid-1990s, as GM closes assembly plants and some Japanese transplant facilities become vulnerable.
- ❏ A major government action to stimulate the US economy may still come, in this presidential election year. AI



Chrysler claims Japanese vehicle manufacturers have been making some $10 billion a year in Japan, while losing an average of about $3 billion annually in the US. A new Chrysler booklet, Cars... America... Japan... Jobs... Facts, *shows profits and losses of those companies in Japan, North America and Europe from 1986 to 1990.*

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AUTOMOTIVE INDUSTRIES

THE PEOPLE — THE PRODUCT — THE PROCESS

Mercedes' newest plant-- blueprint for inefficiency

Why can't Germany compete?

BMW flees the Fatherland

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Cover Illustration by Bob Bernstein

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COVER STORY

German automakers are making the same blunders Detroit made a decade ago

Why can't Ger

by JOHN McELROY

In 1980 German automakers held a preeminent position in the US market. Mercedes-Benz had long eclipsed Cadillac as the pinnacle of luxury and prestige. BMW was becoming the chic choice of every young upwardly mobile professional. And VW commanded $2000 premiums on diesel Rabbits that many Americans saw as the answer to spiraling fuel prices. As far as Detroit was concerned, the Germans posed nearly as much of a threat as the Japanese.

But only a decade later German automakers faded from their lofty position in the American market. As the German mark strengthened against the dollar, as Japanese automakers entered the luxury market, and when US tax law changes in 1986 made it difficult for individuals to write off pricy luxury cars, the Germans suddenly found themselves uncompetitive.

VW gave up trying to assemble cars in the US and last year it saw its sales slide to their lowest levels since the 1960s. From their peak in the mid-1980s, Mercedes sales have dropped 35%; BMW 50%; Audi 75%. Porsche struggled to sell a meager 4400 cars here in 1991.

German automakers are asking themselves, 'What went wrong?' But their darkest fear is that the US market will prove to be a bellwether for what could occur in Europe.

"The United States is the largest, most competitive and dynamic consumer market in the world," noted Eberhard von Kuenheim, BMW's chairman, as he announced his company's plan to build a $250-300 million assembly plant near Spartanburg, South Carolina. BMW believes that if it can not shore up its position in the US market, it will ultimately suffer the same fate in Europe. And BMW believes that building an assembly plant in the US will enable it to introduce new labor-saving techniques and obtain lower non-union wages that it can't get in Germany.

Mercedes-Benz is betting that its new 2.2 million ft^2 assembly plant in Rastatt, Germany is the answer to its Japanese competition. "On a promenade through this exemplary model plant you can see what the future will actually look like," bragged Werner Niefer, president and CEO of Mercedes-Benz AG at the inauguration of the plant.

But are the Germans on the right track? These 'solutions' have a haunting ring to them. They are exactly the same approaches the Big Three undertook in the early 1980s, namely, moving manufacturing operations to lower-cost locations overseas, and making huge investments in new, high-tech facilities. In retrospect, most American executives recognize this was a strategic mistake. They didn't attack their problems head-on. Instead, they tried to manage their problems, or buy their way out of them.

There is no question German automakers face formidable barriers in their home market. German auto workers are represented by I.G. Metall, a strong centralized union that bargains for all production workers at all skill levels (line workers, machinists, etc.) throughout the

The Mercedes-Benz's Rastatt plant is far less efficient than Toyota's Lexus plant.

compete?

country. Every German company also has a dual board: a management board and an supervisory board. The workers are represented on the supervisory board and if it opposes a management decision, management can be forced to rescind or reconsider its position.

This has provided German workers with a standard of living that is the envy of autoworkers the world over, but are a headache for the car companies. Not only do these workers enjoy one of the highest hourly wages in the world, total labor costs to German automakers, including social costs, are roughly $40 an hour. And though Chrysler's labor costs are also $40 an hour, German workers ~~only~~ work an average of 37 hours a week compared to 40 hours in the U.S. The new I.G. Metall contract ~~-~~will drop that to 35 hours a week next year. Moreover, German workers also get 30 days paid vacation a year starting from the day they walk in the door. And that doesn't include 12 paid holidays. Add up the shorter work week, the generous vacation allowance and liberal, recuperation time off for any medical problems and it equals an absenteeism rate of 20% to 25%.

Even major suppliers are now voicing doubts about investing in Germany. "We have grave concerns about Germany's ability to remain competitive given the recent labor agreements, pending social legislation and other things we see on the horizon," says George Schneider, vp of TRW's engine and aftermarket group. Just as General Motors, Ford and Chrysler blamed their non-competitiveness on high wages and too much time off, German automakers have vented their frustration at their hourly workforce. But critics think that German management should be focusing its attention on more serious problems over which it has direct control.

"BMW, Mercedes, VW, Audi, Porsche, Opel and Ford had better all address their problems in Germany. The biggest issue facing the Europeans today is to design for assembly and design for manufacturing. And they have to address how they process a vehicle. When you keep processing a vehicle with low first-time quality, you add so many redundant facilities the plant costs an arm and a leg," says Jim Harbour, a manufacturing consultant (and *AI* columnist) in Troy, MI.

Mercedes' new $1.6 billion assembly plant in Rastatt did indeed cost an arm and a leg, but it represents Mercedes' plan to become more competitive. The plant is organized into groups of 8 to 12 workers who assume responsibility for quality, throughput, the work pace, and other duties. They are also trained in continuous improvement to eliminate waste and re-work.

"In Rastatt we will prove that it can by all means be economically viable to produce motor vehicles in Germany and with a German workforce," said Jurgen Hubbert, a member of the Board of Management at Mercedes-Benz AG and responsible for the passenger car division.

Automotive Industries toured the Rastatt plant a month ago, a tour which revealed serious questions about the

Productivity Comparison

COMPANY	PLANT	EMPLOYMENT	DAILY OUTPUT	(sq.ft.) PLANT SIZE	(est.) MAN-HOURS
Toyota	Tahara	2500	1500	N.A.	13
Ford	Wixom	3735	800	4.2 million	37
Cadillac	Hamtramck	3050	486	3.2 million	50
BMW	Spartanburg	2000	300	1.9 million	53
Mercedes-Benz	Rastatt	5500	360	2.2 million	122

(This chart does not take sourcing, content of absenteeism into account.
It only looks at final assembly. Nontheless, it indicates German automakers are the least efficient.)

plant's competitive standing. To ensure that mistakes are caught at the source, each group works on a car in an assembly bay where they can take all the time they need to build it right. But that means the line has been slowed to a snail's pace. At full production it will make only 23 cars an hour.

But even with that slow line rate, the Rastatt plant uses an astonishingly high number of workers. Fifty-five hundred workers will build only 360 cars a day. *Automotive Industries* estimates that the Rastatt plant would have to eliminate more than 4000 of those employees to match the efficiency of Toyota's Lexus plant in Tahara, Japan (see Japan Report on p.26 in this issue).

Even if Mercedes specifically designed its cars for ease of manufacturing or assembly, it's hard to fathom how Rastatt could match Tahara's efficiency. The work bay concept dictates a tremendous amount of wasted movement in the plant. Cars are moved from one bay to another by automated guided vehicles (AGVs), then are moved to assembly lines, after which they go for more AGV rides. Each car is picked up and moved at least 25 times.

"Clearly they have spent a fortune on the plant and particularly on that equipment to move the cars around. That's going to make the plant suffer a cost penalty for quite an amount of time," says Professor Daniel Jones of the University of Wales and one of the authors of 'The Machine That Changed The World.'

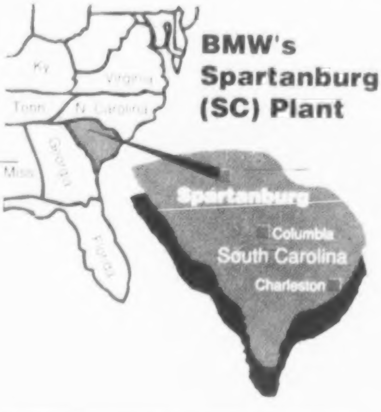
"Plus, there are two big question marks. One has to do with the commitment to a very long work cycle, which fits our description of craftsmanship, but doesn't build in sufficient skill to problem solving—you're doing far too many tasks to be skilled at any of them. Second, how do you assure the pressure and consistency to perform without the discipline of the assembly line? Maybe they can find something that replicates that, but I haven't seen it yet."

When its Spartanburg plant opens in 1995 to annually build 60,000 roadsters based on the 3-series platform, BMW hopes to introduce totally different assembly methods than it uses in Germany.

And by any measure it will be more efficient than Rastatt. Whereas the Mercedes plant will use 5500 employees to assemble 360 cars a day, the BMW plant will use 2000 employees to assemble 300 cars a day. Rastatt will cover 2.2 million ft^2; Spartanburg will cover 1.9 million. And while Mercedes will sink $1.6 billion into Rastatt, BMW only plans to invest up to $300 million.

"This new facility is going to be state-of-the-art. It's going to have all the new concepts BMW has learned from all the automakers around the world. You can play around with plant in Ragensburg, Germany forever, but you're still trying to work with the existing puzzle," says Robert Ady, president of PHH Fantus, a business location consulting firm that helped BMW weed out 250 potential sites around the world over a three-year period, until it settled on Spartanburg.

BMW is likely to cut costs by sourcing parts and components in the US that are cheaper than they are in Europe including stampings, frames, seats, fasteners, transmissions, glass, and interior and exterior trim. But the real savings will come from how BMW will run the plant itself.



BMW's assembly plant in Spartanburg, South Carolina will save $3000 car in labor costs: $400 car in lower wage rates.

"They've made some pretty sound decisions. This will be a new car, and is supposed to be designed for assembly. Most of their cars in Germany take 115 man-hours to build, but the Spartanburg plant is planned in the long run for 40 hours a car at 72,000 cars a year. Total labor costs, at $26 to $28 an hour, will be comparable to the Japanese transplants. They're going to save $3000 per car in having fewer labor hours and they're going to save $400 per car in lower labor rates," says manufacturing consultant Harbour.

BMW plans to export at least half of the plant's production overseas, which will earn it kudos for making a positive contribution to the US trade balance. And the company is keenly aware that the pending North American Free Trade Agreement could allow it to ship freely into the Mexican market. By lowering its costs with a US plant, the company stands a much better chance of competing in developing countries.

"The most favorable interpretation that you could put on this experiment is that it will challenge BMW to expand its thinking beyond Germany. They'll gain a lot from exposure to the toughest market and the most competitive manufacturing environment. The lessons that they can learn will be quite significant and will come back home. They're building in competitive pressures in the company which will force things to change a bit faster in Germany," says Professor Daniel Jones.

Even though BMW seems to have found the answer to many of its problems by building a plant in the US, clearly that approach will not solve the problems facing the German auto industry. A decade ago American automakers also thought outsourcing overseas was the quick-fix they needed to compete with the Japanese. But all that did was re-direct resources that should have been used at home, attacking the big problems that were strangling the American auto industry.

Today, of course, the American industry has outstripped the European automakers in efficiency. But that change came over an excruciatingly long time, and with brutal social and economic damage. Germans would do well to study the American's mistakes and avoid them. But perhaps old habits just die hard.

"It's too early to write the Germans off," says Professor Jones. "But they will suffer some more, and there will be tens of thousands of people who will leave the industry. The Germans may be where the Americans were 10 years ago, but unlike the boom in the market and profits the Americans enjoyed in the mid-1980s, this time the pressure will be sustained. The Germans won't be able to relax." AI

CHILTON'S

SEPTEMBER 1992

AUTOMOTIVE INDUSTRIES

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RECYCLING

WHAT'S THE PROBLEM?

Over 90% of all cars are recycled.
Only 2% of landfill waste comes from cars.
So why does the industry have to do better?

SEPTEMBER 1992 VOLUME 172, NO. 9

CHILTON'S AUTOMOTIVE INDUSTRIES

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Over 90% of all cars are recycled. Only 2% of landfill waste c

RECY

WHAT'S THE PROBLEM?

by LINDSAY BROOKE, GERRY KOBE, JOHN MCELROY AND CHRISTOPHER A. SAWYER

The rush to recycle is on. In Europe, the US, Canada and many other countries, legislators are proposing or mandating recycling legislation to deal with a burgeoning solid waste problem.

It's easy to see why. We are simply running out of places to bury our solid waste. In the US, it is estimated that 85% of the landfills which existed in 1978 will be closed within eight years. Some are either filled or nearing capacity.

Many are closing due to tighter environmental regulations.

Twenty states now have serious landfill problems, according to the Partnership for Plastics Progress (P_3), a plastics industry trade group. And this has caused the price of dumping in existing landfills to double. In many places, the dumping cost is now $100 per ton—and it keeps going up.

Currently, most laws are forcing communities to recycle their packaging and consumer products. But proposed legislation could force the automotive industry to recycle its products. In the US alone, 10 million cars and trucks are discarded every year.

"It's important that those in the automotive industry make recycling happen themselves," cautions Michael Walsh, an environmental consultant who's worked for the World Resources Institute and the EPA. "If instead the industry stumbles all over each other, pointing fingers, the heavy hand of government will come in. And government probably would not handle automotive recycling in an optimal fashion."

What kind of recycling legislation could US automakers face? You only need to look at Germany. Two years ago the German Minister of the Environment, Klaus Topfer, proposed legislation that strongly suggested all automakers in Germany had better develop a recycling system—or the government would do it for them.

To put some teeth behind its action, the Ministry of Environment proposed to reclassify un-recycled automotive materials from "light" waste to "special" waste. That alone could drive the cost of disposing automotive shredder residue—ASR, or "fluff"—to roughly $600-$1000 per ton, up from $100 per ton. Then it gave automakers until December 31, 1993 to develop a recycling system that would take the two million cars that are scrapped every year in Germany, dismantle them, recycle as many materials as possible, and properly dispose of the rest. In response, the Association of Vehicle Manufacturers, or VDA, organized a consortium called PRAVDA to develop an automotive recycling program.

So far, Herr Topfer's talk of legislation is just that—talk. To date, his Ministry has only threatened and cajoled the German automakers, who are still unsure whether they will be the ones responsible for the disposal of their products, or if independent disposal specialists will handle the task.

"The VDA program is the only one that has been developed and we hope the Ministry will adopt it," says Isfried Hennen, a spokesman with the VDA. "But the Ministry has not released its own ideas for its program. They said they will release it this year, but they said that last year, too."

Even so, just the threat of legislation has forced automakers in Germany to "get green." Last fall, VW, Opel and Ford announced they would take back their subcompact cars at the end of their useful life and recycle them. So far, however, none have been taken back. The programs

GERMAN R&D DISMANTLING CENTERS AND RECYCLED COMPONENTS

Company	Dismantling Center	Products made from recycled plastics
Volkswagen	Leer	Golf: bumpers, wheel well liners Polo, Vento (Jetta): bumpers
Opel	Russelsheim (Now Closed)	Astra: bumper beams, wheel well liners, seat moldings, insulation mats; air filter housing
Ford	Cologne	Escort, Orion: to be announced
BMW	Landshut	All models: trunk liners
Mercedes	Tuebigen Neu-Ulm Mainz Alpine-Voest Stahl (independent co.)	S-class: wheel well liners, insulation mats, glove box and trunk liners, bumpers

es from cars. So why does the industry have to do better?

only apply to cars made after October, 1992 and do not apply to cars that are totaled in accidents.

But those automakers, together with BMW and Mercedes-Benz, started R&D programs to develop methods and special tools to dismantle cars. To date, BMW and VW have each dismantled more than 2000 cars. And the methods learned from these R&D programs are being taught to independent disposal specialists working in conjunction with the automakers.

Additionally, German engineers are specifying recycled materials into the designs of their new cars. Opel, for example, already uses 1600 tons of post-consumer recycled plastics annually. BMW is making trunk liners out of recycled bumpers. VW's Golf and Vento (Jetta) models use bumpers containing recycled plastic. Mercedes-Benz uses recycled plastic for wheel-well liners and insulation, as well as in other applications. And Ford of Europe is soon expected to announce which applications use recycled plastics.

To ensure components will be easier to sort and recycle at the end of their useful life, German engineers are reducing the many different types of plastics they specify to just a few.

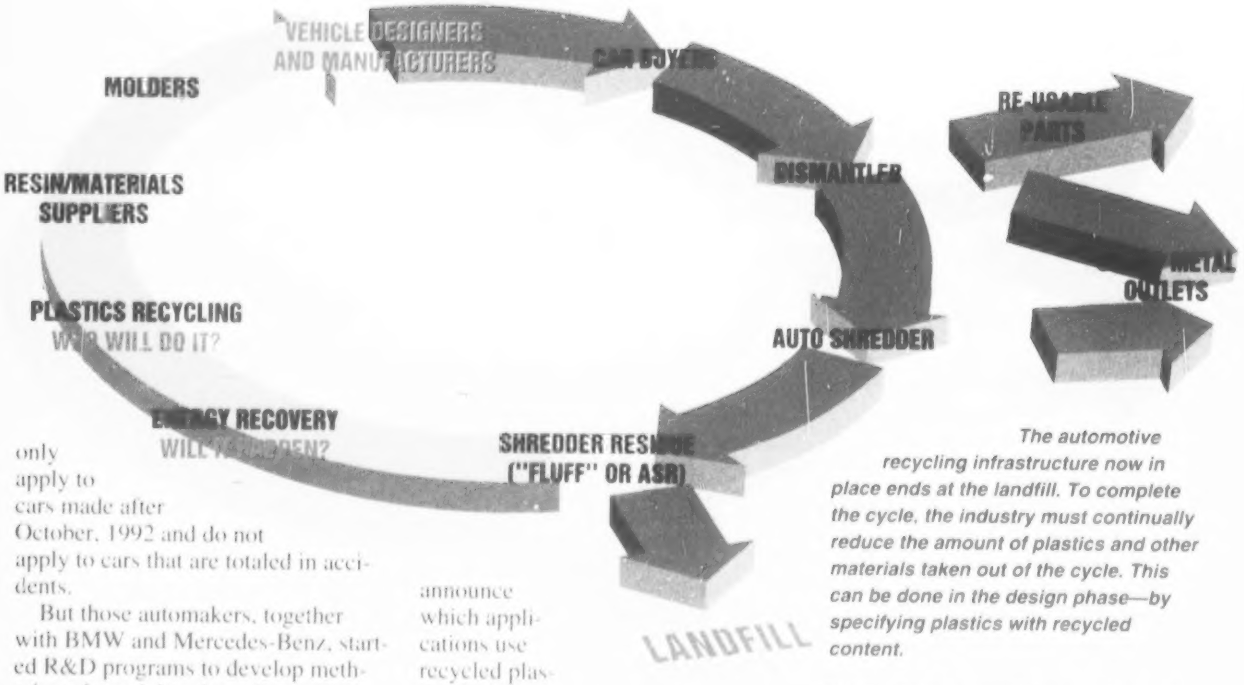
Plastics suppliers take note: Polypropylene and polyurethane are emerging as their prime choices.

Not to be outdone by the Germans, automotive recycling legislation is gathering steam in the US Congress, too. In the Senate, Max Baucus (D-MT), has provided amendments in Senate bill S.976 to the 1992 reauthorization of the Resource Conservation and Recovery Act (RCRA), which directs the EPA to conduct a study on opportunities for recycling automotive components. These amendments were passed by the Environment and Public Works committee on June 16.

Moreover, Robert Torricelli (D-NJ) introduced a bill in the House last year, the "Automobile Recycling Study Act" (H.R. 3369). His colleague Frank Lautenberg (D-NJ) has introduced the same bill in the Senate (S. 1908).

These bills, which have been referred to their appropriate committees, mandate a comprehensive study that, among other things, would set design standards to eliminate hazardous and non-recyclable materials in automobiles.

Cars and trucks attract everyone's attention because they're highly visible products, but they're also among the most recyclable of all durable goods. All together, 94% of discarded vehicles in the US are 'recycled'—a



The automotive recycling infrastructure now in place ends at the landfill. To complete the cycle, the industry must continually reduce the amount of plastics and other materials taken out of the cycle. This can be done in the design phase—by specifying plastics with recycled content.

record that would seem to satisfy even some of the 'greenest' environmentalists.

But it's those 'non-recyclable' materials, particularly plastics, on which the auto industry must act. "Industry complacency," says Dr. Richard L. Klimisch, Executive Director, Environmental Activities Staff at GM, "could be deadly, since 75% of Americans surveyed consider themselves environmentalists."

The auto industry has had a highly profitable recycling infrastructure in place for decades. Some 12,000 auto dismantlers and reclamation yards nationwide remove and sell countless used parts from old vehicles.

When the dismantlers are done, auto shredders recover nearly 95% of the metals, selling the steel, iron, aluminum and copper to eager scrap buyers.

But this system is not very successful at recycling plastics. While the dismantlers have ready markets for a number of plastic parts, they have problems in retrieving many of them from vehicles (see sidebar, p. 51). Until recently, plastic componentry has not been marked to identify the specific resin it's made from, so dismantlers have no idea what type of material they're removing.

In 1991, a new SAE standard (J1344) established uniform coding and labelling of automotive plastics—the first step towards mass recovery of these materials and a key to more efficient dismantling—*if* the parts and assemblies are designed to be easily dismantled.

But automakers will only code parts that are new, or are on new vehicles, or are larger than a minimum size. Any carryover plastic part will probably remain uncoded until that part is changed.

There is also no deadline for automakers to code new parts. For example, not a single plastic part in Toyota's all-new 1993 T100 pickup truck is coded for recyclability, says the truck's chief engineer Shigeo Asai. That's a remarkable oversight, because Asai's team did such a good job of designing the rest of the truck's interior, particularly the instrument panel, for easy manufacture and disassembly.

The plastic bits dismantlers cannot easily remove for sale get shredded and dumped into landfills. About 25% of the original vehicle, by weight, ends up as fluff; nearly one-quarter of the fluff is plastics. The largest auto shredders in the US themselves produce over 50,000 tons of fluff each year.

Millions of tons of high-value plastics will be shredded into fluff over the next decade, until the entire fleet of new vehicles carries coded, easily dismantled plastic parts.

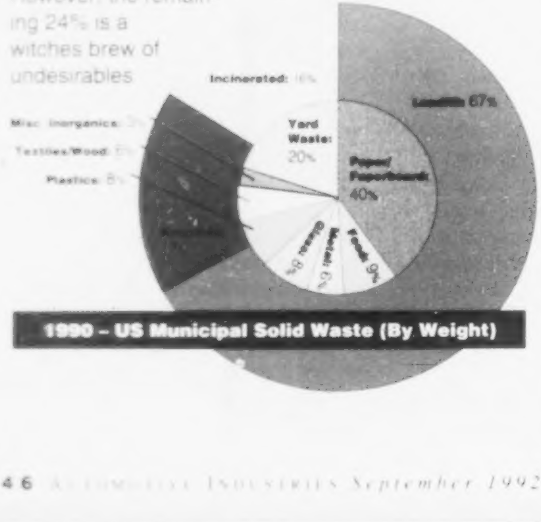
"One of our big problems right now is 'fluff,' " admits Allen Maten, Director of Automotive Programs at the P_3 Automotive Group and formerly a plastics development manager at Solvay Automotive and Ford Motor Co. "We have to figure out how we

How Much Waste is Automotive Waste?

Each US citizen creates about 4.5 lb of waste/day; the US 190 million tons/year. But automotive scrap comprises only 3.8 million tons of that total. Though 10 million automobiles are scrapped annually, the reason such a small fraction of that amount is landfilled is simple.

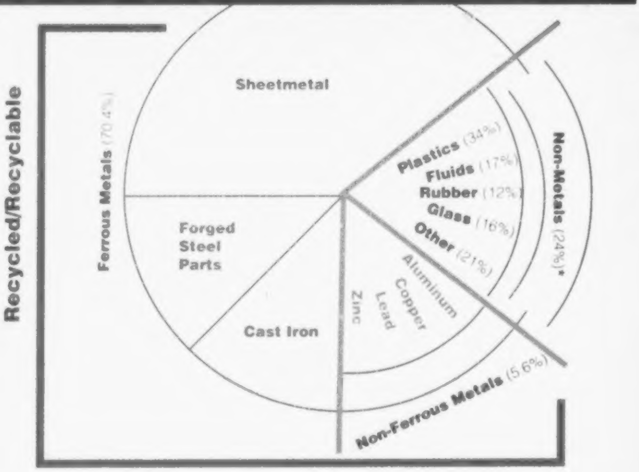
Seventy-six percent of an average automobile is recyclable. Most (70.6%) is accounted for by ferrous metals (sheetmetal, forged steel parts, cast iron), while the remainder (5.6%) is made up of non-ferrous metals (aluminum, copper, lead and zinc). However, the remaining 24% is a witches brew of undesirables that parades under the innocuous term 'fluff.' And it's this material, with its disproportionate volume/weight ratio, that is causing concern.

Fluff, which is also known as ASR, Automotive Shredder Residue, includes plastics (34%), fluids (17%),



1990 – US Municipal Solid Waste (By Weight)

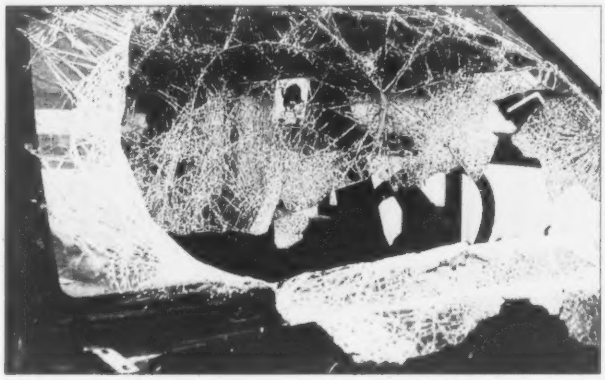
Automobile Composition and Disposition (1991)



* Automotive Landfill 3.8 Million Tons/yr

can get these plastic parts out of the vehicles before they get shredded into fluff."

A certain amount of automotive fluff is good, say landfill operators. They spread it daily as a top-layer covering, because it absorbs, covers and packs down well. And many experts in the chemical industry believe fluff is a potential fuel for generating steam or electricity through combustion. However, while fluff has been successfully burned in laboratory and small-scale pilot projects, those same experts agree that there are major political hurdles to burning it in the real world—among them the "NIMBY" (not in my back yard) syndrome.



Meanwhile, the volume of automotive plastics is increasing: Within eight years, total plastics content of North American-built vehicles will reach nearly four billion pounds. That's roughly 275 lb of engineering plastics on every sedan. P_3's Maten says the chemical companies which make resins know how to recycle the plastics, so the development of viable processes rests with them. And to their credit, many of the major resins producers are well into both development of promising technology and actual recycling, including:

❑ High-volume recycling of polypropylene (PP) battery cases. Himont USA reports that 95%-98% of all US auto batteries are recovered—totalling 150 million pounds of PP annually.

Some 40% of the recovered plastic goes into new battery cases, the rest into other automotive and consumer products.

❑ Recycling of reaction-injection molded (RIM) thermoplastics. Dow Plastics and Miles Inc. have developed a compression molding process where up to 10% of re-ground RIM plastic can be added to new RIM exterior auto body parts during molding.

❑ Recycling of nylon radiator end caps has been studied intensely by DuPont, which is encouraged that the recycling of this material can create opportunities for the recycling of other thermoplastics.

❑ Possible recycling solutions for

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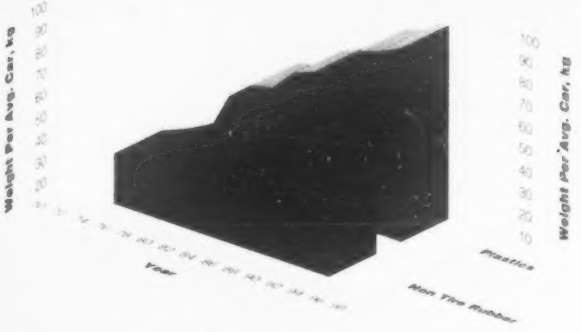
rubber (12%), glass (16%) and other materials like fibers, dirt and contaminants (21%). Almost without exception, they are sent to a landfill.

Last year, approximately 3.8 million tons of fluff were landfilled. And while a sizable slice of the automotive scrap pie, it made scarcely a dent in the overall US municipal solid waste stream. Of the 127.3 million tons of landfilled solid waste in 1990, the automobile contributed less than 3% by weight. Yet this has not stopped the automobile from becoming a target of environmentalists.

Dr. Richard L. Klimisch, Executive Director, Environmental Activities Staff at GM, says the problem facing us today is, "How do we minimize landfill, considering the number of carryover designs and the need to still determine what new designs will need to be recyclable?" Central to that process, he says, is a life-cycle analysis of the car and its parts, as well as an objective look at the various options available—and their costs.

"Recycling may cause a paradigm shift to market-based environmental regulations," says Klimisch, "but not without industry help."

Weight of Reject Material At Body Shredder



When estimates didn't agree, we used the larger of the two numbers—not to overestimate the severity of the problem, but rather to avoid underestimating it. US municipal solid waste numbers were supplied by the EPA, and these have been broken down by segment. Percentage figures for ultimate disposition of these materials were also provided by the EPA, although there were no figures as to the make up of the various sectors.

Figures delineating the material make-up of the average automobile, including the percentages recycled and landfilled are composites of figures provided by Ford, GM, Peugeot, the American Iron and Steel Institute, the Motor Vehicle Manufacturers Association and the Society of Plastics Engineers.

painted or coated thermoset plastics, such as sheet molding compound (SMC), include pyrolysis. This process, tested by General Motors and others, breaks down plastics and rubber and converts them into fuel-grade oil and gas. But pyrolysis is extremely expensive, and the results are still being analyzed to determine economic viability.

❑ Recycling of engineering polyester-type plastics, such as Bexloy K, was proven recently by DuPont, at its Old Hickory, TN methanolysis plant. The company successfully recycled front fenders from the Chrysler LH sedans, mixed with 2-liter soft drink bottles, and spun them into fiber that was used to make sails for the HMS Rose, a tall ship that sailed up the Hudson on July 4th.

❑ Mazda recently developed new reinforced thermoplastic composites which the automaker claims can be recycled up to five times and used continually for structural applications. Many high-quality engineering plastics, once recycled, can only be employed in much lower-quality uses. Mazda also developed a new decomposing catalyst to be used for reclaiming the petroleum content of plastics during recycling.

❑ Instrument panel (IP) substrates have been recycled using either air separation or solvent processes. An Arco Chemical program aimed at recycling the company's Dylark engineering resin has yielded 98%-99% pure resin, which Arco says can be recycled into new IP parts using a 20:80 ratio of recycled Dylark and virgin resin. Opel has recently approved the use of the recycled material in its IP components.

There are many other examples of chemical industry recycling action. What the rest of the auto industry has to do, stresses Allen Maten of the P_3 Group, is "to figure out how to get the plastics off the cars and make it economically feasible for the dismantlers and the others to recycle it. That's our goal. Steel's been doing it since the Sixties, and they've got a real headstart on us. Now it's up to us."

Maten acknowledges that for most non-metallic materials, the automotive recycling 'cycle' is incomplete. Basically, it now ends in the landfill, instead of being a true 'cycle' that ends back at the vehicle engineer and manufacturer. That fact is echoed by Susan Day, a materials engineer and Coordinator of Vehicle Recycling at Ford Motor Co.

"We don't need a new infrastructure in American recycling," Day explains. "We just have some 'holes' in the present infrastructure that we must fix."

Plugging those holes, she notes, is automotive recycling's biggest challenge. That's part of the reason the P_3 Automotive Group was established in 1992 by the Society of the Plastics Industry. "We aren't watching from the sidelines," comments Dr. Michael Fisher, ~~SPI's director~~ of technology.

According to Allen Maten, his Group is now 'digesting' a recent pilot study done in conjunction with US auto dismantlers and shredders. The study emphasized the importance of plastics coding, parts consolidation, dismantler-friendly fastening methods and Design For Disassembly (DFD)—key parts of the 'cycle' which automotive engineers can help sustain.

"We're also looking at other major questions," says ~~Maten. "For instance,~~ will consumers pay some of the costs of recycling? Who's responsible for collecting and reprocessing plastics? How do we expand the currently limited market for recycled plastics?" He adds that a technical cost model has been developed for the recycling of scrapped vehicles.

A major limitation of the existing infrastructure which surfaced during P_3's study is the absence of sufficient reclamation capacity. "There just aren't many plastic reclaimers out there who have the capability to process plastics from scrapped automobiles," explains SPI's Dr. Fisher.

Today, recycling the myriad of plastics and fibers that make up vehicle interiors is a money-losing venture. And since those materials constitute a large percentage of automotive fluff, that's where most automakers' recycling efforts are currently directed.

"We realize that materials in a car right now are pretty good," says Irv Poston, Manager—Composites, GM Advanced Engineering. "It's not a matter of changing them. Certainly we don't want to take out good, value-added materials in favor of something that's more readily recyclable but won't do the job."

Sandy Labana, Manager of Polymer Science at Ford and Chairman of the Vehicle Recycling Partnership, agrees. "Ford issued a directive in late 1991, telling engineers to consider recyclability as one of the design criteria," he says. "But it cannot be at the expense of performance and quality."

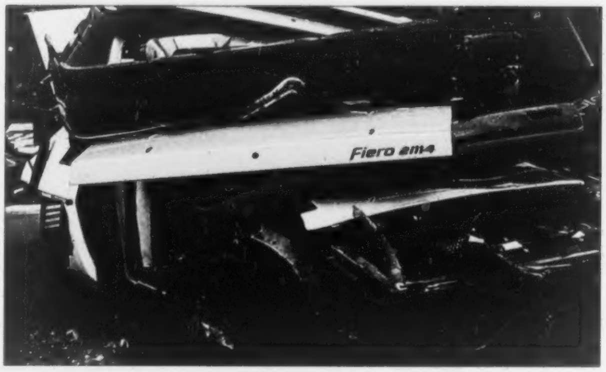
Both Poston and Labana stress that the ideal is to create a design that will be easier and more profitable for dismantlers to handle. Then, if automotive waste is made attractive enough, entrepreneurs will recognize its value, and an infrastructure will create itself. Labana cites an example of how a simple design consideration can improve the recycling of interior door panels.

"We usually make the panel stiffener out of cardboard or Masonite material, and then cover it with foam—perhaps a polyurethane. On top of that we have a fabric made of cotton or rayon, and then cover it all with something like a PVC skin. Now each of those materials is individually recyclable, but the problem is, even if you get the panel off, it requires too much labor to separate the materials. That makes it suitable only for the shredder."

As a solution, Labana proposes that all elements of the door panel—including adhesives—be made of the same polymer plastic, or at least the same family of polymers.

"It's a matter of putting the right materials together," he says. "You don't restrict materials, you restrict combinations. This adds real value to the scrap."

Of course, recovering this material in an efficient manner depends on another technology—DFD. Using



Thirty-four percent of all automotive materials that end up in a landfill are unrecycled plastics.

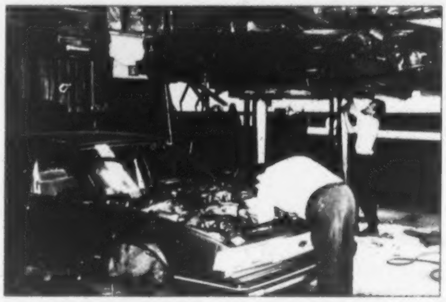
VOICES FROM DOWNSTREAM

What a dismantler says about vehicle design and recyclability.

"This is not a junkyard. This is an automotive recycling and dismantling yard. May we help you?"

This sign, hung in the lobby of Schram's Auto and Truck Parts, proudly displays the credo of this family-run, Pontiac, MI-based auto dismantler. Now operated by the three grandsons of founder Harold Schram, the facility has been taking late-model GM vehicles apart for usable salvage since 1923. It's a superb example of what every dismantler should be—EPA-approved, fully computerized, and working at capacity.

"We completely dismantle two vehicles each day, with one man per vehicle," says co-owner Tom Schram, "but there's enough demand for components and sub-assemblies that we could easily add a second shift." He explains that most vehicles are purchased from insurance companies, typically for $1500-$3000. And each one costs Schram $1500 on average to store, dismantle, inventory, and dispose of the remains.



Obviously, the profit is in the parts. Some yards claim to handle 10 to 20 cars a day, but they only pull the drivetrain and doors, then ship the rest to the shredder. Dismantlers say this is because a) there are no markets for the remaining parts, especially plastics; b) those plastics are not coded, which eliminates their value; and c) it's too time-consuming to remove many items that would otherwise be saleable.

When Schram's sends its bodyshells to the shredder, they're stripped of everything that's not saleable to customers or to scrap dealers. Certain seats are pulled, if they're clean. But plastic and rubber parts are worthless, Schram says. Yards have to pay $1/tire to get rid of old tires.

"The easier it is to remove a part, or a complete assembly, the easier it is to recycle, instead of leaving it in the body to get shredded," notes Schram, adding that his company has worked with GE Plastics on recycling studies, and also did a dismantling study of the plastic-bodied APV minivan for GM. His biggest areas of concern are:

IP ASSEMBLIES: "I think design engineers try to trick us with hidden fasteners," he says. "The instrument panel should be designed for removal as an assembly. Frankly, it was easier to remove an entire dashboard in the 1970s." **PLASTICS IN GENERAL:** "Three concerns here," says Schram. "First, the number of interior parts in GM vehicles has increased. That's the wrong way to go; we should have *larger parts, and fewer of them.* Second, the [SAE J1344] codes are definitely a step in the right direction, but they bring up a bigger question: Will there be a market for all these plastics once they all get coded? Third, seat foam—unless we save the entire seat, the foam always gets sent to the shredder." **GLASS:** "We can easily sell complete windshields, backlites and windows. Unfortunately, we end up breaking 33% of them, because of the adhesives used to hold them in the vehicles. And some glass is really inefficient to remove.

GM's A-cars, for example, are the worst. There's a gasket molded to the glass—the only way to get the glass out is to remove all the interior trim, then heat the glass with a torch and melt the gasket."

DFD, automakers eliminate threaded fasteners, design breakaway parts, mold in access slots for prybars and commonize heads of fasteners that must be used.

This allows for major components to be easily removed and recycled, leaving only small, hard-to-access parts for shredding.

"My opinion is that the best solution is selective dismantling," says Labana. "Not the total dismantling approach they've taken in Germany. If we can take large components off that are optimized for recycling, and grind up the rest for further separation, recycling can be made into a viable business. That will create demand for scrap vehicles."

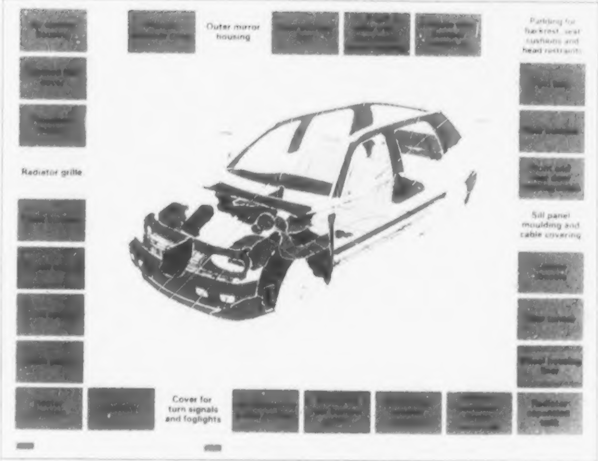
To that end, Susan Yester, Recycling Program Executive at Chrysler, says "We're not working in a vacuum trying to improve the ease of dismantling in our designs. We work directly with dismantlers to learn what is most difficult for them and how we can make it easier."

Of course, if selective recycling is adopted there will still be some residue from shredding operations. And automakers are working overtime to address the problem. In one study, GM shredded 20 plastic-bodied APV vans and put the collected material through the pyrolysis process mentioned above. Poston believes it could be a quantum leap forward in recycling.

"Right now the typical throughput in pyrolysis is one ton per hour," says Poston. "And while that's not real impressive, nobody has tried to ramp it up yet to profitable levels. With our 20 APVs we achieved a significant reduction in material volume and weight, and had only two types of residue remaining. One was a powder that could be used as a strengthening filler in roadbeds, and the other a coarser material that would probably be landfilled.

"From the SMC panels on the vans, we got back fiberglass and calcium carbonate. Both of which can be used again to make more SMC panels."

A different approach to increased recycling is specifying more recycled materials in vehicle components. Right now, the Big Three's smallest member is furthest along.


Outer mirror housing
Padding for backrest, seat cushions and head restraints
Radiator grille
Sill panel moulding and cable covering
Cover for turn signals and foglights
Wheel housing liner

Volkswagen's dismantling center in Leer, Germany is recovering Golf bumpers, and wheel well liners, and bumpers from the Polo and Vento (Jetta). The newest Golf has been designed with much recycled plastics (shown).

"We know what's going on in Europe and we see that coming," says Chrysler's Duane Trimpe, Executive Engineer—Materials Engineering. "We want to get ahead of that and preclude the need for legislation with its restrictive time tables and restrictive way of doing things."

John Fillion, Manager—Organic Materials Engineering at Chrysler, says the company uses recycled material in its headliners, trunk dress-up, sound pads, insulation, glove box liners, sun visors, door liners and headlamp parabolas. He also adds that the company has moved away from painting plastics, choosing to mold in color instead.

"To be honest, the only time we use recycled material is when it's cheaper than virgin material," Fillion says. "But that's our whole approach. We find ways to use recycled goods and achieve a cost savings while doing it. We treat recycled material like any other raw material while evaluating it."

As a side benefit to its recycling efforts, Fillion notes that Chrysler vehicles will be using more polypropylene materials in its future vehicles, and less of a variety of plastics.

"There's no formal move to minimize the number of plastics," he says, "but it's a trend that's driven by cost. Initially, there's a loss of performance in polypropylene over an ABS material, but we've learned to modify it and design around its weaknesses. That will help from a recycling standpoint."

Another discipline that lends itself to the recycling effort is Design For Manufacture and Assembly (DFMA). By its very nature, DFMA prompts engineers to combine parts and commonize materials.

The purpose is to eliminate assembly time for smaller pieces, but in the process it creates fewer parts for dismantling.

Also, one of the objectives for DFMA is increasing the serviceability of a design. This often means less fasteners and a "no tools" approach to removing a part. Through simple design considerations, automakers can create the same profitable "pull" for recycling plastics that exists already for metals.

And if the auto industry can do that, it could raise the portion of a car than can be recycled to 90% from today's 75-80%. Politically, that should be an important goal for automakers.

Even though automobiles only account for about 2% of all the residue that gets dumped in landfills every year, many legislators perceive the auto industry as a politically popular whipping post.

But the benefits of developing a recycling infrastructure go beyond forestalling legislation. If the recycling programs now being put in place come off as planned, the auto industry will do more than reduce its contribution to the solid waste problem. It will launch an all-new industry, one that will provide low-cost materials, and potentially create thousands of new jobs. AI by JOSEPH M. CALLAHAN

THE $25 MILLION JACKPOT

Soaring Big Three stocks have produced a big bucks bonanza for 75 auto executives and directors.

The automotive industry may still be in an overall slump, but many of its top executives and directors are swimming in gravy. Stimulated by a modest increase in vehicle sales, prices of the Big Three common stock soared an average of 63% in the first half of 1992. This produced a paper profit of more than $25 million for corporate directors and company officers who reported stock trades during those six months.

Chrysler stock led the surge with an 80% increase during the period. Ford stock rose 63%, and GM common was up 52%.

The price increases of GM's H and E common stock and the Ford B common are not included in this report. In the first half, Chrysler common jumped $9.37 a share, from $11.75 to $21.12. Ford stock increased $17.75 a share, from $28.12 to $45.87, and GM common rose $15 a share from $29 to $44.

All of this looks pretty impressive for the companies and their corporate officials. But remember that the Big Three stocks dropped significantly less than two years ago. Of course, the genius in this business appears to be Kirk Kerkorian of Tracinda Corp. who purchased 28 million shares or 9.59% of Chrysler common after the nosedive. He made an estimated $262 million during the six-month period as a result of this perceptive buy.

Other big winners in the first half were Chrysler Chairman Lee Iacocca, whose 537,273 shares of Chrysler stock earned him $5.03 million; Ford Director William C. Ford, who made $7.41 million with his 417,911 shares of Ford common; and Ford Chairman Harold Poling, who made a profit of $3.84 million with his 216,515 shares. Former GM Chairman Roger B. Smith, still the largest individual holder of GM stock, made a profit of $875,430 in the first half with his 58,362 shares.

Interestingly, Chrysler officers and directors had an opportunity to exercise their options to buy 4,583,068 shares of Chrysler common during this period, but only sales vice-president E.T. Pappert bought Chrysler stock in the first half. Iacocca owns options to acquire 2,276,000 shares of Chrysler common. A Chrysler spokesman said the Chrysler officials failed to exercise these options because there are only so many "windows of opportunity" in which the insiders could legally purchase the stock as the result of various financial matters. AI

CHART 1

GM EXECUTIVE COMMON STOCKHOLDERS

Roger B. Smith*	58,362
Robert Stempel Chairman	49,037
John E. Smith President	31,399
F. Alan Smith Exec VP	27,481
Donald Hackworth VP	25,255
James D. Johnston VP	23,906
Clifford H. Vaughan VP	23,281
Ronald Haas VP	22,991
J.T. Battenburg VP	22,765
Robert Schultz Exec VP	20,562
John O. Grettenberger VP	20,356
William E. Hoglund VP	20,012
Robert T. O'Connell GMAC	18,634
Charles T. Fisher*	14,766
James Fitzpatrick***	12,753
Edward H. Mertz VP	11,666
John G. Middlebrook VP	10,936
Arvin F. Mueller VP	9,551
Robert J. Eaton	8,468
Richard E. O'Brien VP	8,385
Thomas S. McDaniel VP	7,723
Robert A. Frosch VP	5,537
John E. Mischi***	3,570
Gerald A. Knechtel VP	3,570
Richard M. Donnelly VP	2,880
Shirley Young VP	2,752
George C. Eads VP	2,527
John Higgins VP	2,165
Anne L. Armstrong*	1,500
J. Willard Marriott*	1,000
John J. Smale*	1,000
Dennis Weatherstone*	1,000
Thomas H. Wyman*	1,000
Malcolm R. Currie**	628
Ann D. McLaughlin*	600
Leon H. Sullivan*	500
Thomas E. Everhart*	400
Marvin L. Goldberger*	400
James A. Abrahamson*	226
Michael J. Smith	224
Edmund J. Pratt Jr.*	200
Lester Alberthal**	30

* DIRECTOR ** SUBSIDIARY OFFICER *** RETIRED

CHART 2

FORD EXECUTIVE COMMON STOCKHOLDERS

William C. Ford*	417,911
Harold A. Poling Chairman	216,515
Louis R. Ross Exec VP	92,092
Allan D. Gilmour Exec VP	85,544
Philip E. Benton President	71,030
Peter J. Pestillo VP	43,483
Edsel B. Ford II Ford Credit	38,163
Stanley A. Seneker*	27,155
Colby H. Chandler*	24,000
William C. Ford Jr.*	12,403
Drew Lewis*	7,000
Clifford R. Wharton*	6,000
Kenneth H. Olsen*	5,500
Michael D. Dingman*	5,500
Carl E. Reichardt*	4,000
Roberto C. Goizueta*	3,250
Irvin O. Hockaday*	2,000
Ellen D. Marram*	2,000

* DIRECTOR

CHART 3

CHRYSLER EXECUTIVE COMMON STOCKHOLDERS

Lee A. Iacocca Chairman	537,273
Robert A. Lutz President	47,686
Robert J. Eaton Vice-Chairman	25,000
Jerome B. York Exec VP	17,055
Peter A. Magowan*	15,160
E. T. Papper VP	10,654
Malcolm T. Stamper*	5,516
Joseph A. Antonini*	4,210
Lillian Affinito*	3,196
Joseph A. Califano*	3,196
A. Jean de Granpre*	2,035
Robert J. Lanigan*	1,972
Kent Kresa*	1,910
Earl G. Graves*	1,804
William C. Milliken*	1,396

* DIRECTOR

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by LINDSAY BROOKE

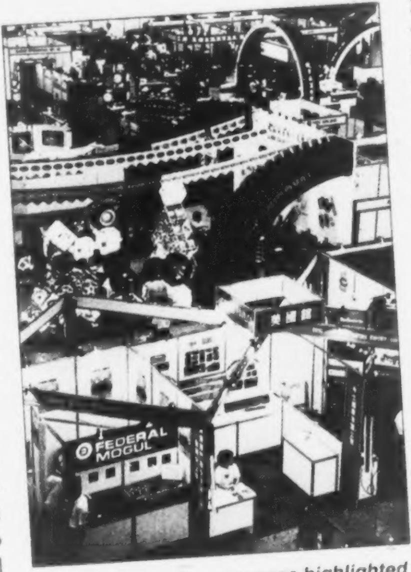
ISLAND OF OPPORTUNITY

Taiwan's consumers are hungry for American vehicles. And its automotive suppliers are equally ravenous to make design and engineering deals with US firms.

Name an American-built vehicle, any vehicle, and you'll probably see it in the Republic of China: from APVs to Grand Ams to Cadillac Broughams; from Chrysler C-cars to Ford Tauruses to Toyota Camrys. Young Taiwanese hot-shoes tool through Taipei's thick city traffic in their Mustangs, Eclipses, Probes and Fieros, dodging oceans of motor scooters. Navistar, Ford and GMC trucks pick up the city's trash and put out its fires. And the cops zoom around helmetless on throbbing white Harley-Davidsons.

The Taiwanese love American vehicles, and their car market has become a ripe plum for US automakers, as *Automotive Industries* found during a recent visit to the 1992 Taipei Auto Show (actually a supplier show), and during tours of Taiwan's leading auto and component makers. In 1991, nearly $600 million worth of new US-built cars were imported—that's $220 million more than from second-place Germany. Total new car sales, including those of Taiwan's 10 domestic makers, were up 15%.

Japanese automakers are prohibited by law from importing their Japan-built cars into Taiwan. Still, Toyota was last year's top importer. It brought in 19,760 units, mostly Kentucky-built Camrys, and in doing so knocked GM into second place among the importers. The General has sold more than 100,000 cars in Taiwan since 1986, and it imported over 20,000 units in 1990. But GM's 1991 tally dropped by 47%, to 12,000 American-built cars and 2432 Opels.



American supplier presence highlighted the 1992 Taipei Auto Show. Can you say "joint-venture?"

"Because of the new Camry," reasoned a Taiwanese supplier executive, who spoke with *AI* at the Taipei Show, "It's this year's hot car." To address its slipping sales and consolidate its Taiwan market, GM will begin to assemble Opel Astras through a joint-venture with Chinese Automobile Co., formerly a sales channel for Yue Loong-built Nissans. By mid-1993, GM and CAC will have a new assembly plant capacitized for over 36,000 Astras per year, on two shifts.

Taiwan's Automotive R&D Plan

Item	1990	1995	2000
Projected Increases in R&D Expenditures	1.5%	3.25%	5%
Projected Increases In R&D Personnel	6.6%	9%	12%

Five principal automakers control about 85% of Taiwan's domestic auto market, but their volumes are small. Ford Lio Ho, generally acknowledged as Taiwan's most efficient OEM, holds a 30% market share. Lio Ho built 104,000 vehicles in 1991. Yue Loong, a Nissan affiliate, made 66,000 units, for a 20% share; Honda's San Yang (of which American Honda owns a 13% share) built 30,000 cars, accounting for a 14% market share. Rounding out Taiwan's 'Big Five' are Toyota Taiwan (10.5%) and Yue Tien (a Peugeot/Daihatsu venture, 9.4%).

These companies have a combined 400,000 unit annual capacity, which was virtually maxxed-out in 1991—they produced 388,645 vehicles, of which only 1292 were exported.

And a recent burst of joint-ventures between automakers has made *AI*'s popular "Global Joint-Venture" wall chart even more useful. Ford Lio Ho entered a technological agreement with Suzuki and GM. Yutyan is working with Peugeot/Daihatsu. Volkswagen in Germany signed a $200 million agreeement with Ching Fong Investment to establish Ching Chung Motor Co. This firm will begin building small trucks in 1993, with 30,000 vehicle annual production slated by 1998. The trucks will be sold in Taiwan and exported everywhere but the US and Germany.

Currently, 50% of all Taiwan vehicle content is locally sourced, down from 70% three years ago. That rate will drop further to spur competition, trade officials told *AI*. The industry's policy is to boost local content rates only on the basis of

Taiwan's Components and Systems Strategy

Component/ System	Planned Year of Completion	Estimated Quantities (units)	Est. Annual Production Value After Completion
ABS	1994	250,000	NT$10b
Steering System	1994	250,000	NT$5b
Exhaust Emission/ Catalytic Converter	1995	500,000	NT$10b
'Common Engines' [1]	1995	200,000 (domestic) 120,000 (export)	NT$20b
Electronic Control Systems	2000	500,000 (domestic) 1,000,000 (export)	NT$40b

[1] Developed by Ricardo and Lotus Engineering   NT=New Taiwan Dollar (NT$1=US$25)

superior quality and pricing. Taiwan's supplier universe consists of 2000 companies of various sizes and levels of expertise. Many of these deal solely in the aftermarket. They exported $835 million in parts and components in 1991.

Supplier Opportunities

Taiwan is already becoming a small but lucrative market for some American OE suppliers, particularly those (such as Allied-Signal) involved in exhaust emissions and catalyst technology. And the potential for more opportunity is huge. The ROC Government has embarked on a massive $350 (US) billion expansion and modernization program for the country's auto industry and transportation infrastructure.

Known as the Six-Year Automobile Development Plan, it aims to upgrade the industry from its present reliance on the aftermarket—often coupled with a reputation for blatant patent infringements and spotty quality—to a global OEM player, capable of designing and producing its own complete vehicles. An electronic data interchange (EDI) system linking suppliers and automakers is also being funded.

Another program, devised by the Taiwan Transportation Vehicle Manufacturer's Association and also funded by the government, will raise industry R&D expenditures and staff levels through the year 2000 (see chart). Included will be the construction of various tech centers and test facilities.

The Taiwanese desperately want to improve their technical capability, particularly that of OE suppliers. In interviews with *AI*, Taiwanese supplier executives stressed their need for US OEM assistance now and beyond the Six-Year Plan's 1996 finale.

"We are building our own OE components and systems industry," said John S.L. Chung, President of the Automobile Parts Manufacturing Committee of the Vehicle Manufacturers' Association, "so we must develop in-house engineering and design capabilities. We hope to establish joint-ventures with American or European companies, to develop new techniques in parts design and production engineering."

Chung noted specific interest in anti-lock brakes, fuel injection and emissions control—systems that are targeted for Taiwanese development and production (see chart above). He said that two 'technology delegations' visited Detroit recently.

Taiwan's first home-grown car, Yue Loong's 'Feeling 102' (yes, there's an obvious need for nameplate refinement, too), was exported in late 1991—a milestone for the industry. But it had a Nissan engine. A major goal of Taiwan's auto industry is to develop its indigenous passenger car engines.

The 'common engine program,' as it was initiated by the Ministry of Economic Affairs, will produce a family of four-cylinder, overhead cam engines, the first debuting in 1995. These will be two 1.6 L engines (with both four-valve and two-valve cylinder heads), and a two-valve 1.2 L. Officials estimate that these engines will help reduce automakers' costs, by eliminating bought-in engines, by at least 30%. Nine Taiwanese automakers, suppliers and machine tool companies are participating in the $200 million project. Britain's Ricardo Consultants and Lotus Engineering are handling the engines' basic design, with ignition system development by Lucas.

There are three main reasons US OEM suppliers should sell in Taiwan and establish links with Taiwanese suppliers, according to Craig Allen, Manager of the American Institute in Taiwan Trade Center:

1. Although 20 of them have received

Eyeing the Mainland

No auto industry in the world is watching mainland China as closely as Taiwan's. When *AI* visited Tamp Auto Parts, a major OE supplier of steering and drivetrain components (and Ford Q1 Award winner), we were given the low-down on China by Dr. Cheng Chen, Tamp Auto's General Manager.

China's current regime "is recognizing that a freer market comes with more plurality," Chen said confidently. He noted that the nine mainland provinces along the China Sea "are already a free market—they'll never go back. And those coastal provinces represent 1.2 billion people. Even if you could get just 1% of the total mainland market, that means 10.2 million people!"

Mainland China now has six automakers—three 'big' ones (Shanghai Volkswagen, Citroën and Falvet), and three smaller ones (Beijing Jeep, Quancho Peugeot and Tienchieu/Daihatsu). "The Communists have said that six carmakers are enough," Chen said. "But vans and small trucks are an exception. That's how Taiwan's auto companies are going to enter the mainland, through small trucks."

—LB

quality awards from the US Big Three. Taiwan's domestic suppliers generally are not world-class.

"US suppliers have a real advantage over the locals in cost, due to their economies of scale," Allen noted. "The guy in the States is making 10 times more than his Taiwanese counterpart."

Allen explained that US suppliers have kept out of Taiwan in the past because the country "is 'off their screens.' They figure these guys are just captives of the Japanese. They don't bother to try here. But Taiwan could become a decent 'niche' market for American suppliers, like it's become for Allied-Signal and TRW."

A logical point for US suppliers to start is with Ford, whose Lio Ho affiliate is widely respected as Taiwan's top automaker in cost, productivity and quality. Allen also suggested that US suppliers which do business with Honda's American plants should consider that company's Taiwanese affiliate San Yang, maker of Civics, Accords and motorcycles.

2. Taiwan's tariff rates have dropped dramatically—from 25% to 15%—and are due to drop again. This makes US products much more competitive. Also, the US dollar is weak in Taiwan; many price-sensitive items can now do well there.

We visited three top Taiwanese supplier plants and were generally impressed with use of SPC, small lot production, cell manufacturing, overall balance of automation and manpower, and cleanliness.

3. Japanese auto companies are virtually frozen out of the market. And American automakers and suppliers have far better name recognition in Taiwan than do the Japanese, say Taiwanese auto executives. The AIT's Allen agrees.

"US suppliers carry prestige names here," he said. "AC Rochester, for example, has a superb image in the aftermarket that will benefit them as an OE supplier." Another factor mentioned in the industry is that the Chinese still harbor painful memories of Japan's conquest and brutal occupation of their country in the 1930s through World War II. When given a choice, they're generally much more receptive to doing business with American companies.

The window of opportunity that now exists in Taiwan for the US automotive industry might soon close. If Taiwan is admitted into the General Agreement on Trade and Tariffs (GATT), there could be international pressure on them to open their market to the Japanese.

"The worst thing the Taiwanese fear is the US replaced by the Japanese here," commented Allen. "That would increase their trade surplus with the US and increase their trade deficit with Japan. The Japanese could then grab between 66% and 75% of the Taiwanese market."

[As of late spring, the Taiwan-US trade surplus was up 49% over 1991 levels, mainly due to consumer electronics, garments, toys and machinery. Taiwan has a $4.03 billion trade surplus with all of its trading partners.] *AI*

A New Breed of Designer

U/E/N Art and Technology is Taiwan's first independent automotive design/engineering company. Its staff represents the 'new breed' of Taiwanese automotive professional—Western-educated, globally focused and eager to make the necessary commitments for success.

U/E/N's point man is automotive design manager Ishun Lin. He's a 1988 graduate of the prestigious Center for Creative Studies (CCS) in Detroit, who worked at GM's Advanced Concepts Center (on the Impact electric car's interior), Renault's design studios in France and at Toyota's Calty studio in California. Lin's four design colleagues at U/E/N are all graduates of CCS and the Art Center School of Design.

Their first complete vehicle was the hit of the '92 Taipei Show—Taiwan's first superbike. Although it utilizes a Japanese four-cylinder engine, U/E/N produced everything—from basic sketches and CAD/CAE work, to clay, fabrication, paint and assembly of the radically styled show bike. And they did it in just four months.

"We combine flexibility, speed and exacting quality in our work," said Lin, as he showed me the details of the animal-looking machine. The headlamps extend telescopically, and there's a built-in digital security system. Body panels are flawless, the overall design provocative and original.

This was U/E/N's first step toward bigger projects, Lin explained. "We now have a project with a Taiwanese automaker for a small commercial van. We're doing the entire process, from sketch to clay to prototype. There's a big market in mainland China for small pickup trucks, vans and motorcycles. We can contribute much to new vehicle designs for any market."

Contact Ishun Lin at U/E/N Art and Technology, Inc. Phone 03-322-2222; fax 03-322-3133. —*LB*

Automated Highways

Japan takes a different approach.

by JIM HAUGEN

According to the Japanese, the most important part of Intelligent Vehicle Highway Systems (or, in their terms, Info-Mobility) is Advanced Vehicle Control Systems—AVCS. They feel that while advanced travel information systems and advanced traffic control systems will improve transportation efficiency, they can only indirectly improve basic problems, like accidents and congestion. The Japanese believe AVCS technology, or automated highways, are needed to provide permanent solutions.

The US IVHS effort, while including AVCS, appears to lack the Japanese conviction. Perhaps the difference is rooted in the accepted view of country cultural differences; the US absorbed with the short-term and the Japanese willing to look more long-term. Or, perhaps, the difference simply reflects differences in need. Japanese space constraints and traffic density make their highway system a much more important, and valuable, asset.

The scope of AVCS is somewhat similar in both countries, ranging from electronic co-pilot systems for collision avoidance to automated highway systems. But major differences exist in the respective approaches.

The US AVCS effort is driven by a Congressional mandate to demonstrate an Automated Highway System (AHS) by 1997. Fortunately, the Federal Highway Administration recognizes that such a demonstration should be only one of many milestones on the long road of development and deployment of a national AHS system.

The immediate FHWA goal is to come out with a Broad Agency Announcement (BAA) on AHS in October. This BAA will lead to the award of five to 10 competitive study contracts. The initial focus is to get on with early concept studies and then select the best of AHS ideas for further development.

Market Penetration of the SSVS Technologies

Phases SSVS Technologies	I by 2000	II by 2010	III by 2020
Obstacle Detection	20%	50%	80%
Road Geometery Detect.	10%	40%	40%
Collision Warning	10%	60%	80%
Auto. Braking/Steering		10%	60%
Pedestrian Detection At Intersections		10%	60%
Driver Assistance At Intersections		10%	60%
Auto. Lane Following			10%

Accident Decrease by the SSVS Technologies

Phases SSVS Technologies	I by 2000	II by 2010	III by 2020
No. of Decreases	415	1896	4090
Ratio of Decreases	4.4%	20.1%	43.4%

The Japanese AVCS effort is termed Super Smart Vehicle Systems. SSVS is outlined as a 20- to 30-year program covering three decade-long phases of implementation. As shown in the attached figure, an astounding reduction in vehicle accidents of up to 43% is expected to result by the end of the third decade. This reduction will be achieved by market penetrations of 10% to 80% of the various AVCS technologies listed. SSVS is being coordinated by MITI and involves 20 or so major organizations—including Nissan and Toyota.

SSVS consists of four parts, with some highly innovative driving concepts embodied within each part.

Part one is termed the Cooperative Driving System. This system will use radar and vehicle-to-vehicle communications to coordinate the movement of vehicles with respect to each other. Each driver, or automated vehicle, as the case may be, will be given information on the maneuver intentions of all adjacent vehicles, especially for lane changing and merging.

Part two is the most unusual. It is entitled Control Configured Vehicle System with Ultra-Little Vehicles. It is an [CONTINUED ON PAGE 98]

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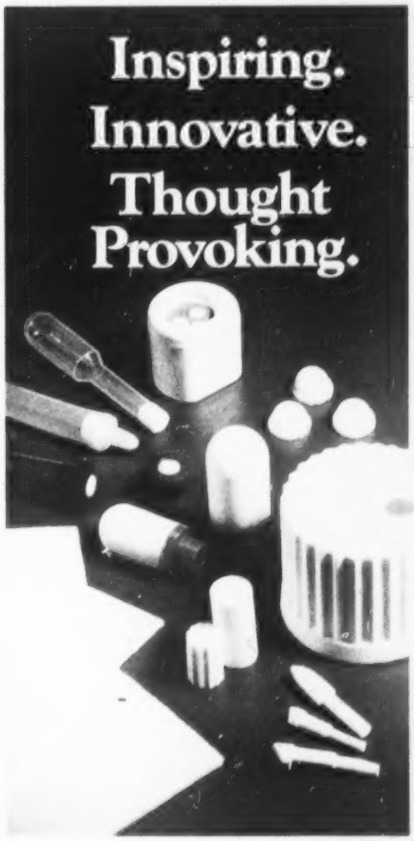

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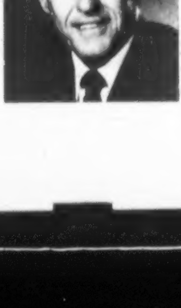
effort to greatly increase the capacity of roadways by the use of small vehicles connected together in flexible group configurations. Each vehicle is intended to be a one- or two-seater with half the dimensions of current cars and only a third of the weight. Two, three, four or even as many as 16 such vehicles (including trucks) might be electronically or mechanically locked together in a 1x2, or up to a 4x4, platoon configuration while traveling on a freeway.

Part three consists of active driver assistance systems. The type of assistance given could range from aged driver or handicap assistance all the way to high-speed freeway driving assistance. In addition, the system would be capable of taking over the driving function for short distances if the driver should doze off or become incapacitated.

The fourth part of SSVS is the Intelligent Intersection System. The intent is to provide drivers much better information as they enter intersections. One idea is to provide drivers with "birds-eye" views of intersection traffic. Another idea is referred to as the "guide light" system. Lights embedded in the intersection road surface would light up indicating each vehicle's intended path through the intersection.

Does all of this sound crazy to you? I'm sure many of the Japanese developments have started out that way. Who would have thought Lexus could compete with Mercedes? I admire their willingness to take risks; to try "silly" ideas, from which, with a lot of development and polishing, come innovative products.

Both the US and Japanese AVCS efforts are going to seem ridiculously visionary for some time, compared to our conventional view of the world of transportation. But remember: "Only he who can see the invisible can do the impossible." AI



Jim Haugen *is an IVHS consultant in West Bloomfield, MI.*

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OCTOBER 1992

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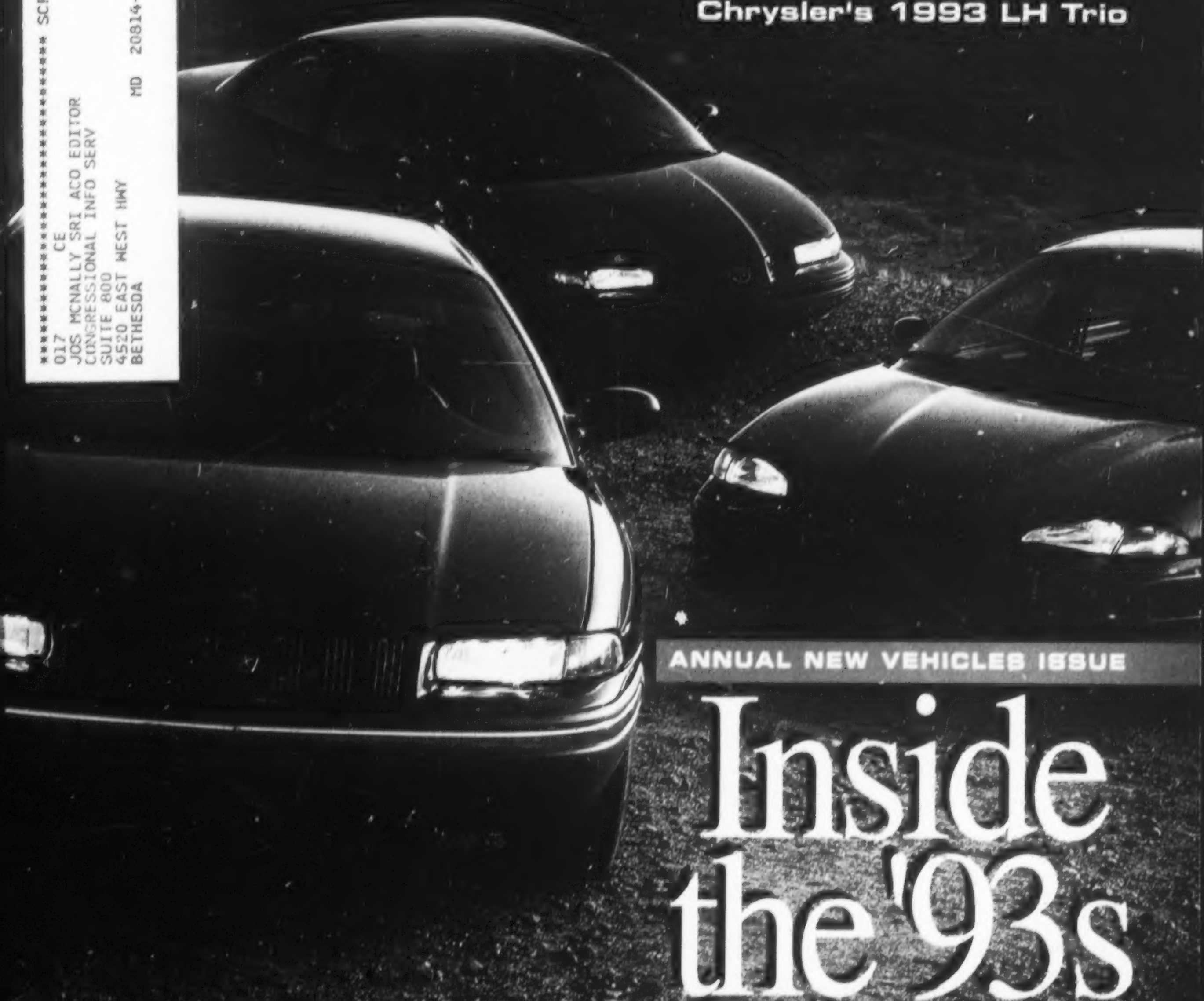
Chrysler's 1993 LH Trio



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by NORMAN MARTIN

ELECTRONICS OUTLOOK: Hot

Demand for automotive semiconductors, relays and 4-wheel ABS skyrockets.

Robust automotive semiconductor purchases have been hammering away at new highs for years, and it's not about to slow down now. In fact, demand for chips will rise sharply for the next two years, says a California-based automotive electronics research team, with a 19% growth rate expected this year and a spectacular 21% leap anticipated next year.

What's more, demand for 4-wheel ABS should climb rapidly through '96, then pancake as the market saturates. The linchpin of the analysis—from a US point of view—is that ABS isn't a Japanese-fueled product. "ABS is a US-driven commodity," says Morris Kindig, president of Tier One in Mountain View, CA. "Those technologies have come out of Delco and Kelsey-Hayes."

In a separate electronics area, long-term downward pressure will not extend to the relay market. Indeed, demand for automotive relays will rise steadily through 1998, primarily due to an increasing number of relays per vehicle.

SHARP GROWTH. Looking back, automotive semiconductor purchases grew from $988 million in calendar year '90 to $1032 million in '91, an increase of 4%, and are expected to grow 19% in '92 to $1225 million. Kindig predicts a 21% growth in '93 will drive the market to $1480 million.

Put simply, in a two-year period the market should rise some 24%. That total excludes captive consumption by GM and a few transplant suppliers, Kindig quickly cautions, but it does include consumption by Motorola AIEG.

GM AND ABS. "You're going to see more and more of it [ABS] incorporated into vehicles, along with traction control," Kindig says. "We're seeing a lot more penetration of that system than we originally anticipated."

Four-wheel ABS rose from 1.5 million units in MY91 to 3.3 million units in MY92, a jump of 120%. "It'll continue rapid growth through [model year] '96 to 10.8 million units, then taper off as the market saturates," he says.

HALL-EFFECT ICs

- Demand up for traction on ice. Use will rise, initially for engines and transmissions. Later, traction control wheel-speed sensors.

LEDs

- Stop. LED market doubled each of the last two years, led by center high-mounted stop lights. Other exterior applications include stop lights and turn signals.
- If and when multiplexed wiring is installed, interior lighting use could sharply expand.

MICROCONTROLLERS

- Multi-use. Low-cost, add-on ABS designs lean toward single 16-bit micro. That's in place of two micros. Users search for a way to use the micro's power to run other functions when ABS isn't used.
- Engine control shifts into the 32-bit area. Prime tragets electronic transmission, traction control, cruise control, variable-valve timing and possibly active suspension.
- If and when multiplexed wiring is implemented, an 8-bit micro will be needed at every node.

SOURCE TIER ONE

MEMORY

- Flash EEPROMs will supplant EPROMs. EEPROMs simplify production and stocking of engine modules.
- Small EEPROMs are needed for ABS as they go from 8-bit micros with EEPROM to 16-bit micros without EEPROM.

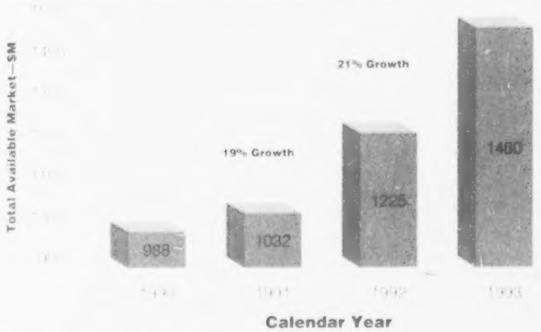
POWER TRANSISTORS

- Compact insulated gate bipolar transistor modules will displace early versions of electric vehicle motor controllers with hundreds of power FETs.
- Delco has shown that its ABS VI using power FETs are the best solution for driving reversing DC motors with high inrush currents. Power dissipation is so low that heat sinking can be eliminated. Power FETs may significantly expand in motor drive applications.
- Most solenoid drives use power FETs, especially in the engine module and ABS module.

VOLTAGE REGULATORS

- Surprise. A market for ASIC voltage regulators has developed. Functions separate of voltage regulation are added—a watchdog timer in an ABS circuit.

North American Automotive Semiconductor Market



Out in the field, General Motors leads Ford and Chrysler installation rates by three model years. Saturn jolted into gear first and now sets the standard.

Transplant competitors will increase ABS installations in '93 and '94 limited by their own capacity. Also, sources tell *AI* that Sumitomo reportedly has a new add-on ABS system that is small and inexpensive. Prime candidates for US use are Ford and Mazda.

TRACTION ACTION. Another ABS-related electronic point of light in the waning years of the decade is traction control. Traction control with four-wheel ABS will become increasingly important in '96 and beyond. Most designs can accommodate traction control by the modular addition of two additional solenoids. Latest designs for traction control combine with electronics as an add-on to the ABS, which greatly reduces the cost of interconnection. Also, the electronic module can be easily removed for maintenance without disturbing hydraulics. Old designs had the electronics in a separate box away from the engine compartment.

Traction control is actually being incorporated now, but at very low and somewhat expensive rates. The Chevy Corvette now offers traction control, along with Chrysler's new LH sedan series.

Even the Penske CART racing team is adopting a traction control system—a first in Indy cars.

HALL EFFECT. In a frustrating and sometimes terrifying area of traction control—ice—at least four companies (led by Siemens) have introduced automotive Hall-effect ICs. Present wheel speed sensors are variable-reluctance sensors—wire wound around a magnet. The sensors work great at high speeds, but not that well at very low speeds for traction control on ice. The innovative Hall-effect ICs operate down to zero speed on a twisted pair line and at very low power.

"They've overcome a tremendous number of problems in the development of Hall-effect IC's," says Stuart Harris, Director of Research for Tier One. "In particular, it will operate for short periods of time at 210°C, which is about 60° higher than everyone else even thought of."

RELAY RACE. Meantime, through an aggressive push, automotive relay purchases rose from $137 million in calendar year '90 to $152 million in '91, a jump of 11%. Harris believes that climb will continue to $169 million in '92, with the '93 market resting at a minimum of $180 million.

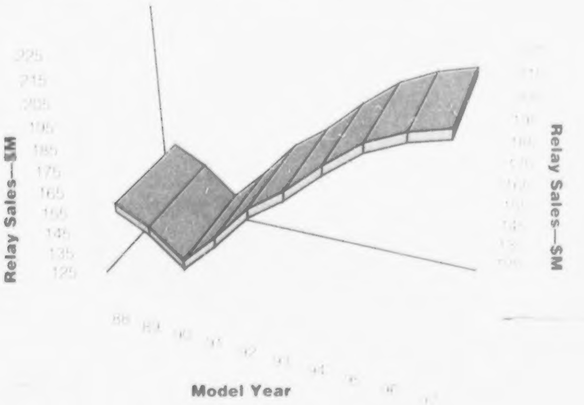
Growth will continue through 1998 because of increasing numbers of relays per vehicle, he adds. OEM accounts for 90% of the market, with the rest split between a rapidly declining replacement market and a fast-growing secondary market of motorcycles, RVs, ATVs and aftermarket.

MINI AND MICRO PLAYS. In the plug-in relay sector, general-purpose relays continue to give ground to mini and micro relays.

Mini relays generally conform to a European ISO standard. Micro or half-size relays will displace mini relays starting in MY92 in Japan for Honda and in MY94 in the US to isolate passenger-seat airbags.

Special-purpose relays are also declining in use here in the US—both in the OEM and aftermarket—except for the Ford starter relay. *AI*

North American Automotive Relay Market, OEM Plus Aftermarket



North American 4-Wheel ABS Market